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Ref: Silicon Chip Mag Nov/Dec 2012

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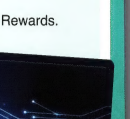

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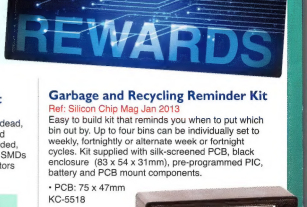

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Ref: Silicon Chip Magazine Dec 2012

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Refer: SC Magazine July 2013

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Ref: Silicon Chip Mag Jan 2013

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Publisher's Letter

E-cigarettes – a new way for smokers to poison themselves

If you're not a smoker or seldom have to put up with "second-hand smoke" from nicotine addicts, you may not be aware of the recent development of "e-cigarettes". While the name suggests these are an electronically controlled cigarette, the reality is somewhat more prosaic in that they essentially contain a battery and a small heating element to vaporise a liquid mixture containing nicotine. Their supposed advantage is that they do not involve the inhaling of tars and the other noxious combustion products of a conventional tobacco cigarette.

Now the reason I am writing about them at all is that while they were only introduced a few years ago, their worldwide sales are already into the hundreds of millions a year, so much so that the big tobacco companies such as Philip Morris are contemplating getting into the market themselves. If tobacco companies see them as a worthwhile product that's a fair indication that they're not! I must say that I loathe anything to do with tobacco and smoking and I cannot see any advantage in people smoking e-cigarettes instead.

I have already seen enough of them being used to conclude that cigarette smokers who change over to e-cigarettes are clearly deluded into thinking that they are better off. There is no medical evidence, so far, to suggest that there is any benefit and they apparently offer no advantage in helping people to stop smoking.

In fact, tobacco smokers may smoke e-cigarettes even more, in the mistaken belief that they are not as harmful. Worse, while those same smokers may previously have gone outdoors to "have a fag" they often now smoke e-cigarettes indoors. So people who used to be exposed to "second-hand smoke" are now being exposed to second-hand "vapour", as it is euphemistically called. "Second-hand poison" would be a better description. Make no mistake; nicotine is a deadly poison; more deadly than arsenic or strychnine, in fact.

And while it is bad enough for adults to be exposed to second-hand vapour (nicotine) from an e-cigarette, I have seen them smoked when children are close by. These days that should be regarded as reprehensible behaviour. More teenagers are smoking e-cigarettes and apparently already young people in the USA are being taken to hospital with nicotine poisoning.

Public authorities in the USA and Europe are already recognising the hazards of e-cigarettes and they are being banned from public spaces. I hope that happens soon in Australia.

Some people who smoke e-cigarettes clearly see themselves as trend setters. I see them as severely deluded. After all, taking LSD was once regarded as trendy by celebrities; most of them are now dead. Just because a new product has the prefix "e" does not make it good or desirable. "email" *may* be good; e-cigarettes are not.

I can see only one advantage for e-cigarettes and that is possibly for people suffering from mental illness who frequently are heavy smokers. This is because, particularly in the case of those suffering from schizophrenia, cigarettes can moderate the symptoms. For these unfortunate people, e-cigarettes may be an advantage in reducing nicotine stains on their fingers, tooth discolouration and decay and so on. If that turns out to be valid, it is still a pretty poor recommendation.

If you know someone who has taken up e-cigarettes, there are two things you can do. First tell them that they are acting stupidly and if they persist, give them a wide berth.

Leo Simpson

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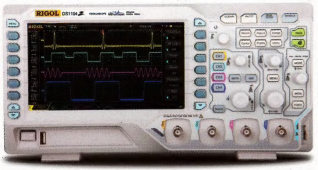

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Civil aircraft flight logs should include video

I read the Publisher's Letter concerning real-time flight monitoring of civil aircraft flight-paths using ADS-B in the August 2013 issue. I was rather disappointed that he didn't take the opportunity to tackle the back-to-back safety issue that piggy-backs onto this subject, namely, "Why is it that in the 21st century we are still dependent on time-consuming and risky search and recovery operations at precarious crash sites to retrieve 'Black-Box' flight-data recorders after serious accidents?"

We then endure the uncertain forensic process of trying to glean usable information from seriously damaged fragments – sometimes unsuccessfully – when it can all be uploaded via satellite-link to secure land-based servers. The on-board recorders would then merely serve as back-ups should an accident occur in a satellite transmission coverage 'black spot'.

However, once you get your feet wet wading into this issue you are immediately confronted with a parallel, related issue; that of the rather arrogant attitude of various airline pilots associations who oppose any attempt to introduce in-cockpit video systems to provide imagery to sync with recorded audio crew dialogue for post-crash analysis. Why do the flying public have to tolerate this elitist drivel from this privileged group who seem to have no scruples when it comes to holding an essential element of aircraft safety to ransom?

It is my view that in-cabin CCTV should be made a mandatory term of pilot employment. If any oppose then it's a simple matter of "the exit's right over there behind you!" Any concerns over privacy are red herrings. The uploaded video would be held securely by an independent body (perhaps IATA?), ie, not the airlines and also subject to tight regulatory control defining authorised personnel access and in what circumstances.

The great hypocritical irony under the current regime is that if a crash investigation nominates "pilot error" as the cause of an accident it is not unheard of for family, friends and colleagues to come out in loud protest when, had in-cabin video footage been available to the investigators, any remaining doubts could have laid to rest, not only in respect of the flight crew but also the passengers' families. One immediate example that comes to mind is SilkAir flight 185 which crashed over Indonesia in 1997 where it was suspected that the pilot deliberately flew the plane into the ground to commit suicide.

So what's the problem with in-cockpit video? To frame this debate you need the right perspective, so consider these examples: taxis and long-haul trucks, buses, trains, hospital surgeries, military aircraft and other vehicles . . . the list goes on. Who, in this day and age, even gives it a second thought unless the worst happens then everyone (and especially the victims and their loved ones) are grateful that

Safety issues with LPG injection

After reading the article regarding the Arduino-controlled fuel injection for small motors by Nenad Stojadinovic in the January 2014 issue, I felt compelled to send you a short letter. I've been dealing with fuel injection systems for well over 20 years, on both OEM and after-market applications. The idea is great but I noticed some glaring safety issues that your readers should consider if implementing this project for themselves.

The use of PVC tubing when dealing with a flammable gas is risky. PVC tubing will be affected by the heat generated during the operation of the engine and could possibly burst or pop off, causing a significant fire risk. Not to mention that after a short time-frame, PVC then hardens and could cause gas leakage without proper clamps installed. Readers would be aware that many small engines use PVC tubing for fuel delivery and this goes quite hard after a short time period.

Readers should ALWAYS use hoses rated for the intended pressure, temperatures and fluids (or gasses), with suitable mechanical clamping devices fitted to the hoses and not just rely on the barbed fittings to retain the tubing. Nenad does mention to keep a fire extinguisher handy!

On a lighter note, a fuel injection system using alpha-N (throttle angle versus RPM) would be more appropriate for engines of this design. Even with averaging of the MAP sensor in the software, the lack of intake manifold volume would most likely cause erratic results as load rapidly changes. Some temperature compensations should be implemented in the code as intake gas density will change significantly as the engine warms up, causing erratic mixture readings. Changes in cylinder head (and oil) temperature directly affect the desired air/fuel ratios.

Also note that LPG burns hotter as there is no cooling effect from evaporating fuel. If the mixture is too lean, bad things happen quickly.

I often see injection systems without correctly configured correction maps, and yes, it does make a huge difference to the tune!

Stu Cornall, MIAME,
Pialba, Qld.

there is some understandable evidence to answer their questions and remove all doubts.

Andre Rousseau,
Auckland South, NZ.

Logistics revolution coming?

I agree with the Publisher's Letter in the January 2014 issue, that deliveries via octocopter may be possible but not practical. However, I think you missed a more important recent news article. Google has just bought Boston Dynamics. Apparently that is its eighth robot maker purchase (check out "Big Dog robot" on YouTube).

Combine a robot arm with a driverless car and you have a package delivery system that can operate during low demand for taxis and at all hours. Be ready to replace your small letter box with a very large "Package Box". It could mean bye-bye to the middle man, with products direct from manufacturer to consumer!

And on the issue of car (or any) manufacturing in Australia (Publisher's Letter, December 2013), I bought a 550g packet of nails recently. These were the cheapest I could find at $5.50 for the packet. This equates to buying a very simple steel product at $10,000 per tonne. The cost is in the same order of magnitude as a car. The feed for making nails is hot-rolled coil at about $650 per tonne.

Yes, there are examples of savings through importing but this is an instance of where the consumers don't benefit! I don't think there any Australian nail makers left.

J. Williams,
Carrara, Qld.

Camry hybrid is a pleasure to drive

May I add some comments to your prognosis, in your December 2013 Publisher's Letter, concerning hybrid cars in particular and electric cars in general? I think I quote you correctly if I suggest the basis of your argument is one of economics.

Parenthetically, before I discuss your contentions, let me say that there are a number of features of hybrid propulsion that I find attractive besides the improved fuel consumption and accordingly, I am on my second Camry Hybrid. The lack of mechanical vibration puts the car up with the most expensive of limousines. Your economic analysis is correct for my situation.

My life ownership cost is more for this car than for the non-hybrid Camry alternative but to my mind, the non-hybrid Camry is an inferior alternative which would not be my comparative car of choice. To get the smoothness I enjoy, I would have to buy a car with a much higher initial price tag which would swing the costings in favour of this hybrid. However, let me go to my main point.

The Toyota hybrids have a power split arrangement, which eliminates a great many expensive components. I do not have a starter motor, alternator, automatic gearbox with the many hundreds of finely manufactured and expensive components nor a torque converter. There are great many expensive mechanical parts which are unnecessary in a power split hybrid design.

It is true that there are a number of power electronic components in a hybrid car which are currently not cheap, like the IGBTs, but if history repeats itself then the cost of the electronic parts will continue to drop. Of course, there is a battery which remains stubbornly expensive at present.

My contention is that if the volume of production was similar to other cars, then the price of the Toyota hybrids should be less, not more, than a conventional car. I think the current costs of the Toyota hybrids are what they can get for the car, not an accurate reflection of the manufacturing costs.

For high mileage usage, which is not my situation, then the life ownership costs favour the hybrid. When I was in New York recently, the taxis there are 100% Toyota. Their operators are reporting a million miles before any major mechanical repairs.

Most of the parts that wear out in a normal car are not there to wear out in this hybrid design. In the stop-start traffic conditions of a place like New York, the mechanical brake pads, for example, never touch the disks. The last hybrid I had still had the machining marks on the disk brakes when I sold it. The air-conditioning compressor is a sealed unit – there is no mechanical seal. I have no "fan belt".

But not all hybrids are created equal. The Honda Hybrid has everything a regular car has with the added components of an electric motor, power electronics and a battery. The manufacturing cost must be more because every part of the non-hybrid car remains in that hybrid design plus extra (expensive) components. Much the same is true of the Peugeot hybrid with its bizarre configuration.

My current model can run for some kilometres under electric power only.

Fuel economy indicator: take a look at ScanGauge

I was interested to read a suggestion from E. J. in the Ask SILICON CHIP pages of the December issue regarding a fuel economy indicator. Having now retired and spending more time on the road, I was also looking for something similar for my 2008 3-litre diesel Prado with which I tow a 1950kg caravan.

After a bit of web searching I found something that seemed to fit the bill, called ScanGauge. It plugs into the OBDII socket and utilises data from the ECU to display a large range of real-time data that can be customised to your requirements. I have mine set to display litres/100km, litres/100km average for the present trip, battery voltage and transmission fluid temperature. This information is displayed in real time. By pressing a button or two, you can recall an enormous amount of information relating to trips, kilometres left to tank empty etc.

You can also scan the ECU for trouble codes. It took me 15 minutes to fit to my vehicle and cost me $189. (ScanGauge II). If you are a bit of a lead foot you will soon see where the fuel is going as the litres/100km reading goes sky high!

It surprised me to see how much additional fuel is used when you are in cruise and the system tries to maintain constant road speed. I no longer use this function unless I am on a long and fairly level highway.

Trevor Moore,
via email.

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Mailbag: continued

There is a switch you press for electric only which locks-out the IC engine. There is an after-market conversion in the US where you can fit additional batteries to these cars which you charge from a wall socket. They simply add the power to the hybrid batteries just like the IC engine might do. You press this electric only button which is there already and the power transfer is regulated by a controller that sits on the data bus and reads off the hybrid battery status. So there are ways to be all-electric.

If you study the design of General Motors' Volt, you could be forgiven for thinking that a dysfunctional committee had designed it. I can see in my mind the whiteboard with people putting red spots after the features they want and the circle of people all talking at once. If you focus on most of the designs, then I am sure your crystal ball is right on the money. However, letting crook designs fall by the wayside is part of the Darwinian principle but they do not all have to go the way of the dodo.

My contention is that, designed properly, like the Toyota cars are and some of the American Ford hybrid cars are, using the power split arrangement and genuinely trying to reduce manufacturing costs unlike Honda and Peugeot and others, then I think the initial purchase price prospects look good for hybrid cars. The smoothness of a hybrid design along with the reduced fuel costs are but an added bonus.

Dr Kenneth Moxham,
Urrbrae, SA.

LED power ratings are over-stated

I can confirm what C. C. (Ask Silicon Chip, January 2014) complained about with respect to LEDs. Every, and I mean every, LED light I bought, whether it was a LED element that ran off DC or a complete LED light that plugged into the mains, measured as using not much more than half the power it was advertised to be rated at.

That overwhelming evidence initially convinced me my cheap power meter was inaccurate, at least at low wattages. So needing to be sure, because I didn't want a row of LED lights I was installing to overload a power supply, I bought a more expensive professional quality power meter. It read almost exactly the same.

Overstating the output and, to make that output seem credible in lumens/watt, overstating the power consumption, is endemic and pervasive in the LED industry. A large part of the power saving you get from them comes from the fact that you install the lumen and wattage you need, but only get a bit more than half of it. Usually that's enough, but it really is a nuisance though when you do need to get a certain illumination level for a workplace and you don't get the expected result.

An example is putting in a dual fluoro fitting and two 1650 lumen 18W LED tubes to get the light output of a single 3200 lumen 36W fluorescent tube. The light output per watt of an LED may beat the hell out of an incandescent and be noticeably better than a compact fluoro but isn't actually much better than a fluoro tube. LEDs just

don't need ballasts or starters, come on instantly and last a number of times longer.

Gordon Drennan,
Burton, SA.

Legislate for commonality of car parts and sub-assemblies

I agree and disagree with the Publisher's Letter in the December 2014 issue. Firstly, we (the taxpayer/Government) can't keep subsidising the local car industry forever. On the other hand, we don't (well I don't) want Australia to end up as a "primitive cargo cult" building effigies on the coast to attract container ships.

The problem as I see it (apart from unions and excessive pay) is the car industry doesn't co-operate. They have been fooled by marketing men into "differentiating their product" (though this is mainly cosmetic) and (more insidiously) by accountants and CEOs into "locking out competition" through non-interchangeable parts.

The commonwealth government, as part of any temporary assistance, should legislate that parts and sub-assemblies should fit together across models (including across manufacturers). If they don't, then they get a penalty (or less subsidy) and non-standardised imports are just banned (or very heavily taxed).

A probable adverse side effect of losing our car industry is that spare parts and maintenance/repairs will be a bigger nightmare (and costlier) than it is now, as imports will be even more varied.

J. Williams,
Carrara, Qld.

Fuel injection article is appreciated

I'd like to say 'hat's off' to Nenad Stojadinivic for his great article about DIY fuel injection. It is one of the best articles I've seen in SILICON CHIP for some time; a perfect combination of hardware, software, dodgy plumbing, ingenuity and of course flammable gasses and sparks. Perfect!

It reminds me of our Kiwi friends and the jet powered beer cooler project: **http://www.asciimation.co.nz/beer/index.html**

Let's have more of these sorts of projects please!

Trevor Luker,
via email.

Ceramic cartridges need a high input impedance

I wish to comment on the query from J. P. on page 101 of the Ask SILICON CHIP pages in the December 2013 edition. Being a serviceman since 1955, I believe that a good ceramic cartridge should work OK into line inputs. In setting up a ceramic cartridge, you need to check the following points. First, closely look at the shaft of the stylus and be sure it is sitting centrally in the activating block. Very gently, try moving the stylus tip sideways. If it is solid, the cartridge is faulty. Note that a lot of "new" cartridges are like this.

To improve bass response we used to fit a "loading" resistor as recommended by the makers. We fitted a 470kΩ

Mailbag: continued

More uses for SDR dongles

SILICON CHIP has had some good stuff on SDR projects. How about using SDR dongle to receive and decode pager signals? Most people think that pagers are dead but they are still used for mission critical one-way comms (we all know of SMS messages that arrive a week late).

I am an RFS volunteer and the NSW RFS makes extensive use of pagers to summon volunteers to respond to an incident. Reliability and cost are two of the reasons for using pagers. However, I happen to work just outside the range of the nearest VHF pager transmitter, hence can't receive pages and have to rely on one of the members calling me during working hours.

It would be great if I could use a TV dongle and your SDR software to grab and decode the page and then send it as a text to me. The text bit I can organise though a commercial SMS provider. The local system transmits on 148.5875MHz and I think they use that in many places in New South Wales.

www.discriminator.nl/pdw/index-en.html has done some work on decoding pager signals. I believe that POSIG 512 baud is common to all NSW RFS pagers and CAPCODES are used for the individual pagers. The user would need to find their own capcodes.

I was thinking that you could avoid using an external audio line or modifying a scanner and feed the signal from the SDR direct into PDW; it may be more reliable.

Regarding the article on using SDR for DMR digital P25 reception in the December 2013 issue, most of the P25 traffic is unencrypted in rural areas. Certainly the police and RFS are unencrypted. Some areas use trunking but we use PMR in the Southern Tablelands for the RFS with GRN trunking as backup.

Neville McMartin,
Yass NSW.

resistor in most cases. If the volume was then inadequate we reduced the resistor to 270kΩ. The loading resistor will reduce the treble but it reduced record scratch. This can be improved by fitting a 1000pF capacitor in parallel with the resistor.

David Littlely,
Yokine, WA.

Comment: loading the cartridge with a 470kΩ resistor and shunting it with a 1nF capacitor may have been standard practice in the days of valve amplifiers but it would not give good results with the line inputs of solid state equipment which typically have an input impedance of no more than 50kΩ or 100kΩ, at best. In those cases, adding a 470kΩ resistor and capacitor would have negligible effect on the output signal.

So these days, the only practical approach to obtaining the best sound from ceramic cartridges (or piezoelectric transducers in the case of musical instruments) is to use a separate preamplifier which provides an input impedance of 5MΩ or more. The load impedance needs to be this high because piezoelectric transducers are essentially a voltage source in series with a capacitor, typically around 500pF.

However, anyone wanting the best sound quality from vinyl records would be well advised to use a turntable fitted with a high-quality magnetic cartridge and then use a preamplifier which gives the correct RIAA/IEC equalisation. The magnetic cartridge will give much better signal quality and because it uses a lower tracking force, causes much less long-term wear and deterioration the records themselves.

Use a brass cleaning pad for soldering iron tips

I thought I would pass on some useful information about electronic temperature controlled soldering irons. For many years, I've used one of these soldering irons to do electronic projects of one kind or another. Some of them came with a pad that was made damp so one could clean the tip of the iron before using it once more. Eventually I purchased another iron with similar tips but it came with a dry brass pad on which to clean the tip. After a while, I found that my iron tips were lasting many times longer than if they were cleaned with a damp pad. I wondered why this was so.

After some research, I found out that if you put your iron tip onto a damp pad, the temperature of the tip would suddenly drop thus causing many small cracks to appear on the surface. Wearing out of the tip was much faster with the damp pads. Since a single tip costs between $10.00 to $12.00, the savings have been quite considerable. In addition to this the brass pad keeps the tip far cleaner than the damp pad.

Glen King,
via email.

Shortest route around Australia

The discussion on the shortest direction to travel around Australia is probably as a result of confusion over a well-known fact amongst caravan travellers. Due to the presence of the Central Australian High Pressure System, the prevailing winds, on average, travel anti-clockwise around the Australian continent. Looking at a map showing the direction of sand ridges around the continent confirms this.

Thus with a tail wind, vehicle speeds are easier to maintain, fuel efficiency is significantly improved and a more relaxing trip is the result. This is most noticeable at the greater latitudes when crossing from Perth to Melbourne. Anti-clockwise is the way to go.

Bob Backway,
Belgrave Heights, Vic.

Another view on power generation

I read with interest a letter from Paul Miskelly in the Mailbag pages of the December 2013 issue. In the real world though, money is the common denominator, with (under privatisation) the power companies striving to purchase/generate the cheapest power possible and get the best return from customers, so as to inflate their profits.

This has resulted, as the price has risen, in a reduction of the power consumed and hence the generation capacity needed. People switch off/

Raspberry Pi software problems

I have been having a go at the Raspberry Pi XBMC idea and have run into quite a serious difficulty. The editor of our local magazine "The Shed" had a similar article and also has run into problems with software updates causing improper operation or making some functions cease to work.

As far as I can gather, a lot is due to the "open ended" form of the Raspberry Pi's software. We know that Linux comes on a plethora of versions and these, together with the multimedia software itself, seem to give rise to a whole lot of problems. The problem seems to be that one has to get a system going, then, quickly, turn OFF any automatic upgrades. You can't backtrack as in Windows!

What would be interesting is some feedback on other readers' experiences with this idea. This would have to be very specific about the versions of the software packages used in their working version.

When I looked up the entries devoted to this system I came across literally dozens of versions and every bit of advice was "version specific" to a very high degree. So much so that what at first appeared to be a lot of help, rapidly evaporated.

This even applied to making the system recognise an 8GB memory stick!

Clifford Wright,
Helensville, NZ.

use more efficient ways to save money. Australia has a unique Grid Authority system, whereby the authority holds an auction every few minutes, with the successful tenderer supplying the grid for that period with a given amount of power. This results in the generators being divided into two groups.

The first of these are base load, eg, coal-fired power stations. Starting a coal-fired boiler from cold takes between eight and 24 hours before steam is available. Once running, the most efficient operation is continuous for long periods of time at a constant load. The power output generated is dependent on the amount of steam supplied to the turbine and hence can vary from almost nothing to full output.

The generator can be switched off grid and maintained in idle run mode but this necessitates either exhausting surplus steam to atmosphere (noisy, inefficient) or slowing the amount of steam generated by burning less fuel; not easily or quickly done. Resumption can be in the order of minutes. A complete shut-down takes up to 24 hours.

So, these generators quote for base load, to their maximum capacity, at a rate of about six cents per kilowatt-hour and run their plants at this rate for days or weeks at a time, as this is the most profitable. Victoria has a capacity, at full load, of about 6500 MW, spread over three companies with 11 generators of between 200 and 800MW capacity each. Currently, Energy Australia has reduced its capacity by 25%, probably in a bid to force up the base load price it receives. This system can supply any load required but makes the most money when run as base load generation, running at full capacity.

The secondary generator group comprises wind and other renewables. Wind turbines can be turned on or off in a matter of minutes, simply by rotating the turbine head into or out of the wind direction. The output is dependent on the wind, needing a speed of about 3m/sec for generation to start. Most wind farms are in areas with constant wind speeds of 6m/s or more.

Output increases with wind speed but can be adjusted by varying the blade angle as required. Wind farms are located in areas with high and constant wind speeds. They are available for an average of more than 90% of the time, so can be used for base load power. Norway and Portugal do just this, having up to 90% of their power supplied by wind. The wind systems being installed in England's North Sea are for base load generation (eliminating coal-fired stations!) The effect of weather patterns has a very small effect on capacity, as the wind very rarely stops completely.

In Australia, with the geographical diversity and interconnection, adequate power is always available to the grid to cover any local shortfalls; hence

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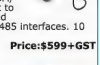

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Mailbag: continued

PIC projects & firmware

Thank you for publishing such a good general electronics magazine. I very much enjoy your PIC microcontroller based projects but I have noticed over the years that the format of the accompanying article for each of the PIC projects has not changed from when the projects were non-microcontroller based.

Many of the PIC microcontroller projects have more than 90% functionality contained within the firmware. The PIC project articles seem to avoid discussing the firmware design used, principles of operation and perhaps novel ways of using the internal functions of the PIC concerned. In many cases the project commentary is imbalanced; the hardware design can be so simple that it really doesn't deserve the commentary that I often see written, where as discussion of the firmware can be completely omitted in some cases.

What would be nice would be a deeper discussion on the firmware design, for example what registers are used for what, I/O and timing functions, the general flow of the program, special precautions and perhaps discussion on any unusual use of the in-built functions of the PIC etc; and last of all tips and advice on modifying the firmware – where any come to mind by the author.

A flow chart of the code and key register use for specific purposes would also be much appreciated. In some cases, the ASM listings are lacking useful explanation of the code operation.

I realise that space in the magazine is at a premium given the need for advertising but as a regular reader I would very much appreciate more in-depth articles on the assembly or C code and would happily forgive you for adding more pages of advertising to cover the cost.

Alex McLeod,
via email.

no backup generators are needed.

The average generator puts out about 2MW over most of its operating time. Note that Victoria has the largest wind farm in the southern hemisphere, and South Australia is approaching 40% of its consumption from wind power. There is no backup generation of comparable capacity, as it is not required for this purpose.

As the aim is to maximise profits, the wind generators do not bid for the base market but rather wait until more power is required before entering the market. With the ability to switch on or off as required, profitable operation will occur, even when only operating for 10% of the time. As peak power can reach figures like $10,000 per MWh, it pays to wait in the bidding process.

When load is low, the coal stations can easily carry the load, reducing their output if required. The wind system is turned off. As the load increases, the wind system is turned on for short periods. As the load rises further, the wind system is turned on for longer and longer periods, until finally, at peak load; the wind system is fully turned on.

Operating statistics tell us nothing about operational availability but reflect only the financial returns to the generators and the way the system operates to achieve this. Hydro systems operate in the same manner but as they purchase power for pumping (at low cost), need to operate more frequently so as to supply power (at higher cost) and hence make a profit.

David Tuck,
Yallourn North, Vic. SC

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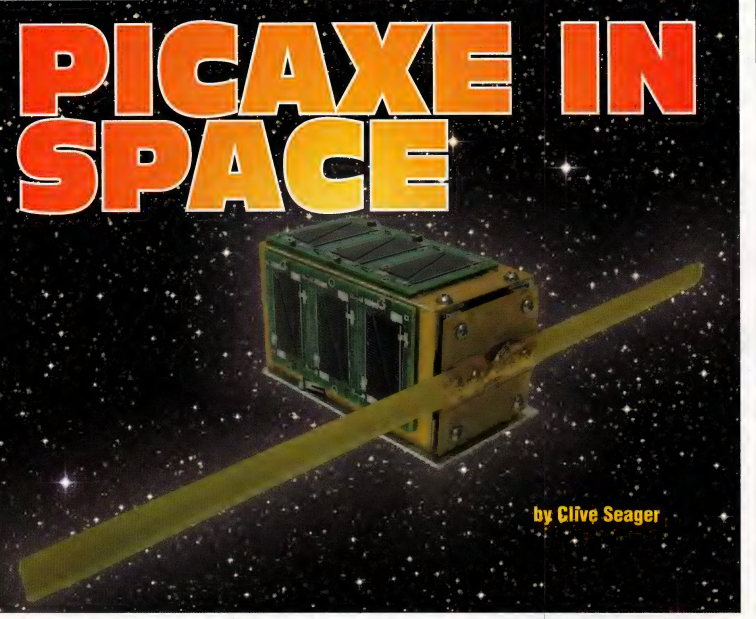
PICAXE IN SPACE



by Clive Seager

At 07:10 UTC on November 21st 2013 Kosmotras successfully launched a Dnepr rocket from Dombarovsky Air Base (Russia), carrying the United Arab Emirates' DubaiSat-2 and 31 other satellites. One of these was not much bigger than a cigarette packet and cost less than $200!

Apart from the fact that this mission set a new record for the most payloads (32) carried into orbit by a single rocket, one of those satellites, Unisat-5, itself carried internally a number of smaller sub-satellites including four CubeSats and the very first four PocketQube satellites. These were launched almost immediately after Unisat-5 itself was deployed.

One of these satellites was controlled by a PICAXE microcontroller.

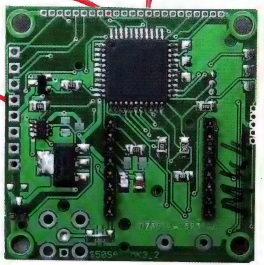
PocketQube is a new class of miniaturised satellites developed by Professor Bob Twiggs, a professor at Morehead State University, Kentucky, USA, who, together with Professor Jordi Puig-Suari designed the larger CubeSat class.

PocketQubes use a 'unit' size one eighth the size of the previous CubeSat standard – with a '1-unit' length now measuring just 50mm.

'\$50SAT' as it is affectionately referred to by its developers (its official designation is Eagle 2) is a 1.5 unit, 210g, PocketQube satellite controlled by a PICAXE-40X2 microcontroller. \$50SAT has been an international collaborative education project between Professor Bob Twiggs and three radio amateurs, Howie DeFelice, AB2S, Michael Kirkhart, KD8QBA, and Stuart Robinson, GW7HPW.

\$50SAT was deployed successfully and is now fully operational, orbiting Earth at around 7.5km/s at a distance of around 600km.

At the time of writing it is not known if it will be large enough to be accurately tracked by Norad by itself but it can still be tracked fairly reliably using the larger 'Unisat-5' it was launched from.



Both sides of the PICAXE and radio motherboard PCB. That's not much to control a spacecraft, is it!

The primary purpose of $50SAT was to create a 'proof of concept' that could be used as a cost effective platform for engineering and science students to use for developing real-world skills.

The PocketQube form factor has no precision mechanical parts and can be built in a school workshop from locally-obtained 1.5mm sheet aluminium. Professor Twiggs was very keen to support the use of the PICAXE microcontroller as it is very low cost and can be simply programmed in BASIC, without the need for C or assembler programming skills, making it ideal for high school students.

$50SAT is comprised of a sheet aluminium cube covered in solar cells. Internally it is quite bare, just two main 40mm x 40mm circuit boards stacked above the battery. The first is the processor/radio board which contains the PICAXE 40X2 microcontroller programmed in PICAXE BASIC, the Hope RFM22B single chip radio transceiver and some peripheral devices such as a DS18B20 temperature sensor.

The second board is the power control and monitor board. This board contains four maximum power point controllers, one for each solar array on each side of the spacecraft as well as current monitors for the battery and summed solar power. The battery is an 'off the shelf' Klic-7002 lithium ion digital camera battery, charged by the solar panels to a maximum of 3900mV.

The $50 nickname was the original budget the development team thought would be the hardware cost. Unfortunately the cost of the high tech triple junction solar cells blew that budget in one hit but you could still build one yourself for around US$200.00

All the circuits, PCB artwork and PICAXE BASIC programs are available on the designer's website.

Listen in on 70cm

$50SAT operates in the 70cm amateur radio band and transmits a slow morse beacon around once a minute, as well as a fast morse beacon and FSK RTTY. All transmissions from and to $50SAT are at the same frequency, 437.505MHz (but allow up to ±10kHz of Doppler shift).

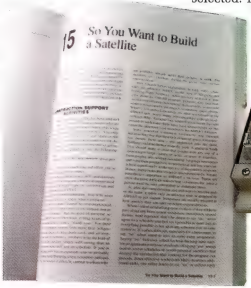
The FSK RTTY sent out by $50SAT is best detected using a 'Funcube' USB dongle with a omni-directional antenna but the slow morse should easily be heard using standard amateur radio receivers and has even been heard on low-cost UHF hand-helds.

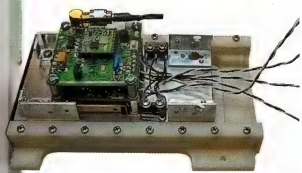
The initial communications requirements at design stage were to:

1. Transmit a slow Morse call sign identity.
2. Provide remote command uplink to turn radio transmissions off (a requirement of all satellites).
3. Operate at a programmable frequency in the 70cm amateur radio band.
4. Include a method of getting data back on solar panel and battery performance.

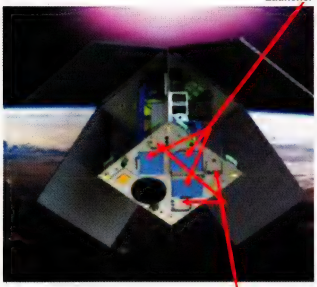
Radio on board

The small size of the satellite made it difficult to find a ready-built radio transceiver for communications. There are special radio modems designed for use in CubeSats but they are either not low enough in cost or not small enough for use in the smaller 50mm PocketQube. Therefore the off-the-shelf US$5 Hope RFM22B FSK data transceiver was selected. The RFM22B is based on the Silicon Labs Si4432 device and has a mere 100mW transit power. If you look carefully at the photos you will see





So you want to build a satellite? Go right ahead: one of the aims of the project was to provide a model for a low-cost satellite which was within the capabilities of high school students.



Unisat 5 with PocketQube launchers.

what that folding dipole antenna is built from – yes, it re is a tape measure purchased from the local hardware st

The 'FM' morse is not true FM as such but is generat by the PICAXE microcontroller switching the RF transceiver between two different carriers.

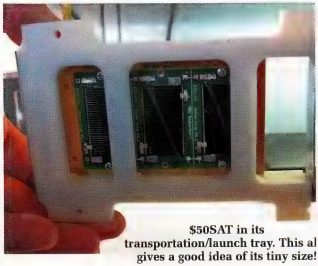
The data transmitted includes battery state, idle/rece transmit currents, solar charge current and voltage and as temperature (measured by a common DS18B20 sens

Summary

At the date of writing (late November 2013) the des ers are delighted with the performance of the satellit is working exactly as designed and is living proof th working satellite really can be built on a shoestring buc by students using 'off the shelf' components such as PIC microcontrollers and radio transceivers.

Now who do you know who is launching a rocket v room for a (admittedly tiny) extra payload?

Congratulations to all those involved. The sky is no lo the limit for back shed tinkerers – space has no limits



$50SAT in its transportation/launch tray. This al gives a good idea of its tiny size!

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Super Smooth, Full Speed Controller for

by John Clarke

This 10A electronic speed controller provides an impressively smooth running universal motor that can be adjusted from very slow up to full speed. Using the feedback control, the motor can be set to maintain its speed even under load.

A similar 230VAC 10A Full-Wave Brush Motor Speed Controller was published in May 2009. This controller worked well but this latest controller has additional features which give a significant improvement over the earlier version.

This includes improvements to the motor control along with added protection to the controller circuitry such as cycle-by-cycle over-current limiting and soft starting.

We need to mention here that this controller is ***not*** suitable for use with induction motors, such as are typically used with compressors, bench grinders, lathes and pumps. For more information see the panel entitled: What motors can be controlled?

Why is it so good?

So why is this controller so good at driving brush-type motors, particularly at slow running speeds and for full speed operation?

It is all to do with the type of voltage waveform that is use to provide speed control.

Typically, brush motor speed controllers use a simple phase-control circuit. We published such a phase-controller for brush motors in the February 2009 issue.

Shortcomings of phase control are immediately apparent when using this design. One is that the maximum speed from the motor when under full speed control adjustment is significantly reduced – up to 25% or more – compared to running directly from the mains.

Why build this when you can buy a power tool with inbuilt controller?

Many hand power tools these days have inbuilt (trigger or dial) speed controllers. And many cost less than this stand-alone controller kit. So why would you build this one?

Quite simply, this is better! That's no idle boast – everyone who has tried this out has been very pleasantly surprised. You won't believe how smooth the control is, nor how much "grunt" you get at low speed. Or any of the other features this new 230V 10A Universal Motor Speed Controller offers! **It's not just better than any previous controller – it's significantly better . . .**

Or perhaps you have an existing favourite power tool that doesn't have speed control: build this and enjoy new versatility!

range, 10A/230V Universal Motors

Most mains motor speed controllers aren't very good! They often have very poor low-speed control or won't allow control right up to the motor's maximum speed. Or both! Here's one that is exceptional: a microcontroller-powered full wave circuit that overcomes both these problems and gives extremely smooth control as well. It's ideal for use with electric drills, lawn edgers, circular saws, routers or any other appliance with universal (ie brush-type) motors, rated up to 10A.

So for an electric drill that normally runs at say 3000 RPM, the maximum speed might be reduced to around 2200 RPM. This is inevitable with a controller circuit that effectively half-wave rectifies the 230VAC mains waveform to give a maximum output voltage of around 162V RMS.

The second drawback of the February 2009 phase control design has to do with low speed control. While the circuit *does* allow your drill or other appliance to run at quite low speeds, the result is that there isn't much torque available and the speed regulation is poor.

This means that if you're operating the drill at a low speed and you put a reasonable load on it, its speed will drop right away or it may stall completely.

Worse still, the motor will tend to 'cog'. Cogging is caused by erratic firing of the main switching device (a TRIAC) within the Drill Speed Controller, so that the motor receives intermittent bursts of power.

An electric motor that is cogging badly is virtually useless and the only cure is to increase the speed setting, defeating the purpose of a speed controller if you want to operate at low speed.

What's the alternative?

Both of these drawbacks are basically eliminated with the new SILICON CHIP Motor Speed Controller.

The design does not use phase-control circuitry but uses switch-mode power supply techniques to produce an outstanding controller for all types of universal brush motors. (Virtually all mains-powered [handheld] power tools and many appliances use universal motors. These are series wound motors with brushes.)

It has very low speed control with excellent maintenance of speed under load. Additionally, it will run the motor over its full speed range, even at full speed if required.

Most power tools will do a better job if they have a speed control. For example, electric drills should be slowed down when using larger drill bits as they make a cleaner cut.

Similarly, it is useful to be able to slow down routers, jigsaws and even circular saws when cutting some materials, particularly plastics (many plastics actually melt and then meld if the speed is too high).

The same comments apply to sanding and polishing tools and even electric whipper snippers – they're less likely to snap their lines when slowed down.

Phase control

Before we continue, we should explain what we mean by phase control so we can illustrate the benefits of this new design.

As you know, the mains (AC) voltage closely follows a sine wave. It starts at zero, rises to a peak, falls back to zero, then does the same thing in the opposite direction. This repeats at 50 times each second (50Hz).

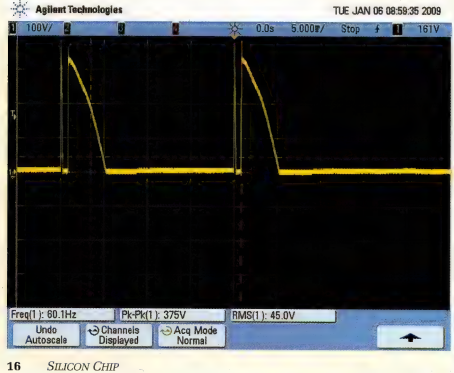
A motor connected to the mains

Features

- Extremely smooth and precise motor speed control
- Speed can be controlled from zero to maximum
- Superb speed regulation under load
- Adjustable speed regulation with feedback control
- Excellent low-speed motor operation
- 2300W (10A) rating
- Cycle-by-cycle current overload protection
- Over-current limiting
- Soft starting
- NTC Thermistor for initial surge current limiting
- Fused protection
- Rugged case with interference suppression included
- For 230VAC brush (universal) motors

These waveforms illustrate the operation of a typical phase-controlled SCR when driving a typical electric drill. In Fig.1 (above) the SCR is triggered early in the positive half-cycle, so the motor voltage is 138V RMS and it runs at a relatively high speed. The motor can never run at maximum speed for another reason: half of the energy is unavailable because only one half of the cycle is used. (Even if the whole half cycle could be fed to the motor, it could only ever be about 162V RMS). Also notice that there is considerable hash at the beginning of each positive half-cycle, caused by interaction between the drill's commutator and the Triac.

Compare this with Fig.2 (below) where SCR is triggered much later in the half-cycle, meaning less power is available to the motor – the voltage being fed to the motor here is just 45V RMS. While it does run much slower – the aim of the exercise, of course – it suffers from low torque and is also liable to "cog". Note the frequency error in both these screen grabs, which is caused by hash on the waveform and the fact that the SCR triggering is erratic.



makes full use of the energy from each cycle so that it runs at its maximum speed. But if we were only to supply a portion of the waveform, with less energy available to power it, the motor would not run so fast.

By varying the time during each half cycle when power is applied, you would have a variable speed control.

This then is the basis of phase control: feed power very early in the cycle and it runs fast; delay power until much later in the cycle and it runs slowly.

The term 'phase control' comes about because the timing of the trigger pulses is varied with respect to the phase of the mains sine wave. Phase control has in the past been the basis for incandescent lamp dimmers and even heater controls.

By the way, phase control is not generally suitable for fluorescent and compact fluorescent lamps.

The oscilloscope waveform of Fig.1 shows the chopped waveform from a phase-controlled circuit when a motor is driven at a fast speed. Fig. 2 shows the waveform from the phase-controlled speed control at a lower setting. At the low setting the motor has 45V RMS applied, while at the higher setting, the motor has 138V RMS applied to it

These examples show only the positive half of the mains waveform being used, as is the normal case with a phase-controlled circuit. This automatically limits the amount of energy which can be delivered to the motor – the power available from the negative waveform cycles is not used.

It means that in a half-wave phase-control circuit, the range of control is limited to a relatively small range of speeds.

For the motor to run at full speed, it would need to be fed with both the positive and negative half-cycles of the 50Hz mains waveform.

Normally this is not possible with a phase-control circuit that uses an SCR (Silicon Controlled Rectifier), which is, effectively, a controlled diode that only conducts in one direction.

While a TRIAC could be used to switch the full 50Hz mains for phase control (ie, both positive and negative-going half cycles), it is difficult to achieve and still incorporate constant speed control under load without a complex circuit.

Additionally, another big problem

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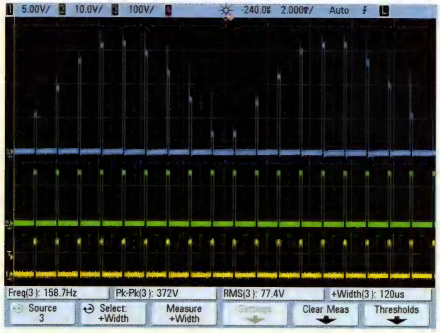


This series of scope screen grabs, taken with the controller driving a typical handyman electric saw, show the voltage wave-forms applied to the motor at progressively higher speed settings. Fig.3 (above) is the lowest setting with very short pulses from the IGBT delivering just 77.4V RMS to the motor. The yellow trace shows the output from IC1 (as applied to the IGBT driver), while the green trace is the output from that driver. The top (blue) trace shows the voltage actually applied to the motor via the GPO. You can see that it follows the follows the full-wave-rectified mains "outline" but the pulses themselves are very narrow.

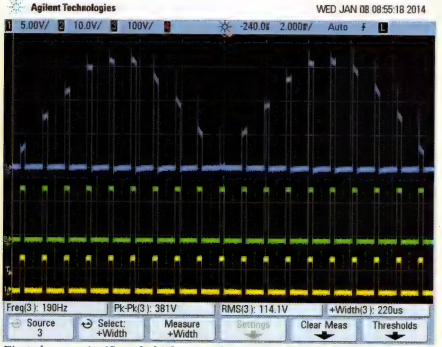


Fig.4 shows a significantly higher speed setting (114V RMS) with the IGBT being switched on with longer pulses. The yellow and green traces remain constant in their amplitude but of course the pulses are wider, therefore delivering more energy. By the way, the spikes on the leading edges of the motor waveform (blue trace) mainly appear to be an artefact of the measurement method (ie, they are not actually present!).

with conventional phase-controlled circuits is that the trigger pulse applied to the TRIAC or SCR is very short.

If this corresponds with the instant when the brushes hit an open circuit portion of the commutator, no current will flow and the motor will miss out on a whole cycle of the mains waveform.

Similarly, even if the TRIAC or SCR has been correctly triggered on, the SCR or TRIAC may switch off again as current falls to zero when a brush passes an open circuit on the commutator.

This problem is more critical at low speed settings and is one of the reasons for the 'cogging' behaviour referred to earlier.

Incidentally, the sparks you see when you look into a universal (brush type) motor are mostly caused by brushes passing over the open circuit section of the commutator.

Typically, a power drill might have a dozen or more open circuit sections on the commutator. These open circuit sections or gaps in the commutator are necessary to keep motor windings separate.

Speed regulation

Most phase-controlled SCR or TRIAC speed control circuits claim to include a form of feedback that is designed to maintain the speed of the motor under load.

They rely upon the fact that a motor can be used as a generator when it is spinning with no power applied. When the motor is loaded and the motor speed slows, the back-EMF (electromotive force) produced by the motor drops and the circuit compensates by triggering the SCR earlier in the mains cycle. This earlier triggering helps to drive the motor at the original speed.

In practice, however, the back-EMF generated by most series motors when the SCR or TRIAC is not conducting is either very low or non-existent. This is due in part because there is no field current and the generation of voltage is only due to remanent magnetism in the motor core. If there is any back-EMF produced, it is too late after the end of each half-cycle to have a worthwhile effect on the circuit triggering in the next half-cycle.

So while phase control is simple and cheap, it is not an ideal method for controlling motor speed. Instead

we use a different method as follows:

Pulse-width modulation

The new Silicon Chip speed control circuit uses Pulse Width Modulation (PWM) and a different feedback method for speed regulation that effectively solves the above problems associated with phase control. Fig.3 to Fig.6 show the voltage waveforms applied to the motor at progressively higher settings from very low to full speed.

What happens is that we rectify the mains voltage and then chop it up at a switching rate of about 980Hz using a high voltage IGBT (Insulated Gate Bipolar Transistor). For the lowest speed setting (Fig.3), the pulses are very narrow and for the higher speed settings the pulses applied to the motor are progressively wider.

There are between 9 and 10 pulses during each half cycle, so the motor receives a more continuous stream of current compared to when driven via phase control. As a result, the motor operates very smoothly over the whole of its speed range.

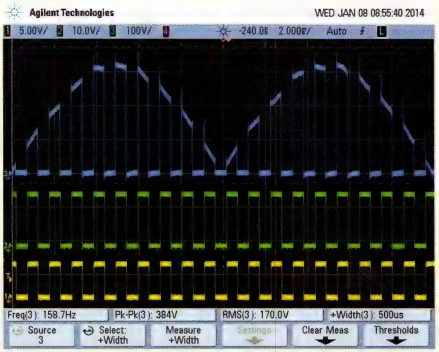
For speed regulation, the circuit does not rely upon the back-EMF from the motor. Instead, it monitors the current through the motor and adjusts the pulse width to maintain the motor speed. When a motor is idling, it draws a certain amount of current to keep itself running. When the motor is loaded, the motor speed drops and the current drawn by the motor increases. The motor controller senses this and then compensates for this speed drop by widening the pulse width to maintain motor speed.

Block diagram

Fig.7 shows the basic circuit arrangement. The 230VAC input waveform is fed through a filter and full-wave rectified.

An NTC thermistor in series between the full-wave rectified supply and the motor limits the initial surge current drawn by the motor. The thermistor has a relatively high resistance when cold; as it heats up, the resistance drops allowing full power to be applied to the motor when necessary. The NTC thermistor is ideal for use with heavy current appliances to reduce the start up current.

The resulting positive-polarity waveform is fed to one side of the motor. The other motor terminal is switched on and off via IGBT Q1.



Similarly, Fig.5 shows an even higher speed setting – very close to 50% duty cycle – with now 170V RMS being delivered to the motor by the IGBT. Motor speed would already be higher than that capable of a phase-controlled circuit and shows how good this circuit is.

Incidentally, all the waveforms displayed in this series of figures have been measured using high voltage differential probes on the oscilloscope. Do not attempt to make any of the measurements using conventional probes and an isolating transformer – as there is a risk that you will blow the IGBT, the fast recovery diode, D1 and the gate driver chip, IC3. We write this from bitter experience!

Fig.6: here the IGBT is virtually full-on delivering maximum voltage to the motor. The drive pulses are virtually at 100% so the motor would be running at the same speed (or very close to it) as it would if plugged directly into the 230V AC mains. However, the RMS voltage reads a little lower than expected, due to the fact that the spikes which were present in the earlier waveforms are no longer there to confuse the scope.

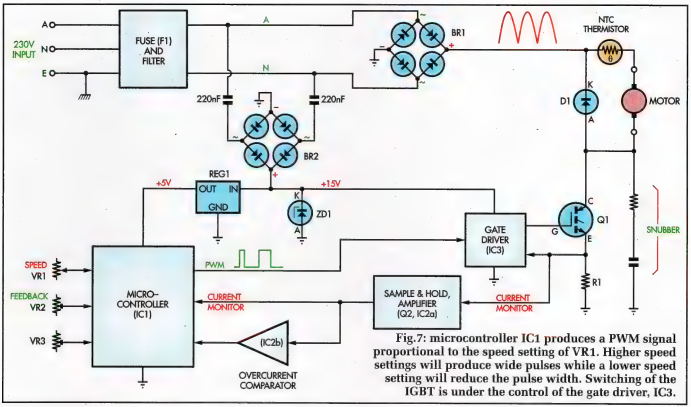


Fig.7: microcontroller IC1 produces a PWM signal proportional to the speed setting of VR1. Higher speed settings will produce wide pulses while a lower speed setting will reduce the pulse width. Switching of the IGBT is under the control of the gate driver, IC3.

An IGBT is a hybrid of a Mosfet and bipolar transistor. It has the high impedance gate drive of a Mosfet but high current handling at high voltages, like a power transistor.

The IGBT we are using has a 40A, 1200V rating (120A peak) and can even withstand a short circuit for 10µs. Switching of the IGBT is under the control of the gate driver, IC3, which in turn is controlled by the microcontroller, IC1.

IC1 monitors the speed potentiometer VR1 and produces a PWM signal that is proportional to the speed setting. So for higher speed settings of VR1, the PWM output from IC1 will be wide pulses while a lower speed setting will reduce the pulse width.

The PWM output is fed to IC3 that then drives the high voltage IGBT (Q1). Diode D1 is a fast-recovery type to conduct the motor current when Q1 is switched off.

The "snubber" across Q1, consisting of a 33Ω resistor and 10nF capacitor, suppresses excessive voltage excursions.

The very low value resistor, R1, is included for monitoring current flow through the motor. This current measurement is used for two purposes. Firstly, the current is monitored by IC3 and this IC will reduce drive to the IGBT should the current go beyond a peak of about 23A. This IC monitors the peak current during each switching cycle to protect the IGBT from damage due to over current.

For speed regulation, the voltage across R1 is filtered, sampled and amplified. Sampling of the current occurs only whenever Q1 is switched on to drive the motor. The current feedback is held at this sampled voltage level when the motor is switched off. The amplified current measurement is monitored by IC1 and averaged over a 10ms period thus capturing a full half mains cycle of current.

An over-current comparator is included and is also monitored by IC1. It differs from the cycle-by-cycle, peak over-current protection provided by IC3.

It works as follows: whenever the average current exceeds 15A, IC1 begins to reduce the duty cycle of the PWM drive until the comparator output switches low, indicating a lower current. It thus provides an overall current limit.

VR2 and VR3 are for the feedback control. VR2 is a potentiometer that's externally adjustable as it is mounted on the lid of the controller. Alternatively, if you prefer not to have VR2 mounted on the case lid, then VR3 can be used to set the degree of feedback. VR3 is a trimpot installed inside the controller. The feedback control adjusts by how much the duty cycle of the PWM motor drive is increased under load.

One of the advantages of using a microcontroller is that the feedback control can include features not possible with conventional circuitry.

Firstly, when starting the motor from stopped, any feedback control is inactive until the motor reaches the speed that it is set to run at by the speed control. This motor-start operation can be activated by turning the speed control up (from fully

Specifications

Rating:	10A, 230VAC
Speed adjustment:	Zero to motor's maximum
PWM frequency:	980Hz
Cycle-by-cycle current limiting:	23A peak
Average current limiting:	15A
Soft start rate:	Up to 2.54s from zero to full speed
NTC thermistor:	10Ω at 20°C, <0.1Ω @10A

Parts List – 10A 230V Motor Speed Controller

1 PCB, code 10102141, 112 x 141mm
1 metal diecast case, 171 x 121 x 55mm (Jaycar HB-5046)
1 front panel label, 168 x 118mm
1 10A single switched mains power outlet (GPO) (HPM CDXL787WEWE or equivalent)
1 240VAC 10A PCB mount EMI filter (Jaycar MS-4000) (or Schaffner FN 405-10-02 or equivalent)
1 NTC Thermistor (SL32 10015) (Element14 Cat.1653459)
1 10A IEC mains lead (3-pin mains plug to IEC line female connector)
1 IEC male chassis connector with fuse (Altronics P 8324, Jaycar PP-4004)
1 10A M205 fast blow fuse (F1)
2 knobs to suit potentiometer shafts
2 2-way PCB mount screw terminal blocks with 5.08mm spacing (CON1)
5 6.35mm PCB mount male spade connectors with 5.08mm pin spacing (Altronics H 2094)
5 6.35mm insulated female spade quick connectors with 4-8mm wire diameter entry
2 5.3mm ID insulated quick connect crimp eyelets with 4-6mm wire diameter entry
1 18-pin DIL IC socket
1 M4 x 10mm pan head or countersunk screw (Earth to case)
1 M4 x 10mm countersunk screw (Earth to lid)
2 M4 x 15mm pan head screws (GPO Mounting)
1 M4 x 20mm pan head screw (BR1 mounting)
5 M4 nuts
4 4mm star washers
2 M3 x 10mm countersunk screws (for IEC Connector)
2 M3 x 15mm pan head screws (for Q1 and D1)
8 M3 nuts
2 3mm star washers
2 M3.5 x 6mm screws (supplied with case) (for mounting PCB to case)
4 stick-on rubber feet
6 100mm cable ties
2 TO-3P Silicone insulating washers
1 400mm length of blue 10A mains wire
1 400mm length of brown 10A mains wire
1 400mm length of green/yellow 10A mains wire
1 200mm length of brown 7.5A main wire
1 200mm length of blue 7.5A mains wire
1 70mm length of black 5mm heatshrink tubing
1 10mm length of red 5mm heatshrink tubing
1 40mm length of 2.5mm Vidaflex heat resistant sleeving

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 1010214A.hex (IC1)
1 LMC6482AIN dual CMOS op amp (IC2)
1 IR2125 PDIP current limiting single channel Mosfet/IGBT driver (IC3)
1 LP2950ACZ-5 5V regulator (REG1) (Jaycar ZV1645)
1 STGW40N120KD 1200V 40A NPN IGBT (Q1) (Element14 Cat. 2344080)
1 2N7000 N-channel Mosfet (Q2)
1 STTH3012W 30A 1200V TO-247 ultra fast recovery diode (D1) (Element14 Cat.1295262)
1 1N4148 general purpose diode (D2)
1 15V 1W zener diode (ZD1)
1 35A 400V or 600V bridge rectifier (BR1) (PCB mount; Altronics Z 0090) or (with quick-connect terminals; Jaycar ZR-1324 with additional components required. See below)
1 W04 400V 1.2A bridge rectifier (BR2)

Capacitors

2 100µF 16V PC electrolytic
5 1µF 50V monolithic multilayer (MMC)
1 470nF 63V or 100V MKT polyester
2 220nF 250VAC X2 class MKT polyester
1 100nF 250VAC X2 class MKT polyester
4 100nF 63V or 100V MKT polyester
1 15nF 63V or 100nF MKT polyester
1 10nF 250VAC X2 class MKT polyester
1 470pF ceramic

Resistors [0.25W 1%] #=1W, 5%

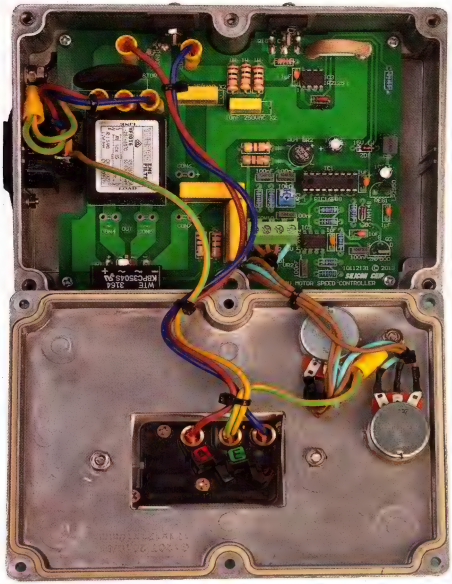
2 1MΩ #	1 1MΩ	3 10kΩ	1 4.7kΩ
2 2.2kΩ	1 1kΩ	2 470Ω #	1 330Ω
3 100Ω #	1 10Ω	1 4.7Ω 0.25W 5%	

2 24mm 10kΩ linear single gang potentiometers (VR1,VR2)
1 0.010Ω 3W low ohm shunt resistor (TT Electronics, Wellwyn OAR3 R010) (Jaycar RR-3420)
1 10kΩ miniature trimpot (horizontal mount with 5mm pin spacing) (VR3)

Extra parts required for BR1 with quick-connect terminals:

4 6.35mm PCB mount male spade connectors with 5.08mm pin spacing (Altronics H 2094)
4 6.35mm insulated female spade quick connectors with 4-8mm wire diameter entry
1 80mm length of 10mm diameter heatshrink tubing

We have been advised that Jaycar Electronics will be producing a kit for this speed controller: Cat KC5526 will sell for $149.00 and should be available from all Jaycar stores next month.



Ready for next month's construction details, here's the inside view of the new Speed Controller. It's fully self contained within a rugged diecast box.

anticlockwise) or by switching on the motor. The lack of feedback control prevents the motor giving a large overshoot in its speed when it first starts up. A stopped motor is detected as being each time the average motor current drops to zero.

Secondly, the microcontroller can "dial out" the idle (no load) motor current so motor speed is not increased markedly with increased feedback settings. If this is dialled out, only the extra current drawn by the motor under load is used by IC1 to adjust PWM to maintain motor speed. This feature is especially useful with higher-current motors.

The motor idle current is dialled out by running the motor at the speed required with the speed control and with the feedback control set to its minimum setting. The motor's idle current will then be recorded by IC1 and feedback will only operate when motor current exceeds this current.

Any changes that increase the motor speed, either through a change in position of the speed control or starting the motor, the PWM signal is varied at a slow rate with small increases made each 10ms.

For a complete ramp-up in motor speed over the possible 255 speed settings, full PWM duty is only available after ramping up over 2.54s.

Circuit description

The circuit for the Motor Speed Controller is shown in Fig.8. It comprises three ICs, several diodes, resistors and capacitors plus the high voltage IGBT, Q1. Power for the circuit is derived directly from the 230VAC mains.

The entire circuit floats at mains potential and is therefore unsafe to touch whenever the circuit is connected to the mains. Also note that the circuit ground is floating at mains potential (it is not connected to mains earth which connects only to the metal case).

Mains power supplied to the controller circuit is via a fuse, F1, that's integral to the IEC input connector. This fuse protects the circuit against excessive current flow such as can occur with a short across the motor.

An Electromagnetic Interference (EMI) filter reduces switching artefacts from the IGBT and motor being radiated back to the mains wiring. This is a commercially-made filter that consists of a pair of 2.2nF to 3.3nF capacitors from Active and Neutral to Earth, followed by a 0.3 to 0.4mA current-compensated series choke for each line, then a 15nF to 100nF capacitor across the load terminals (actual values depend on manufacturer).

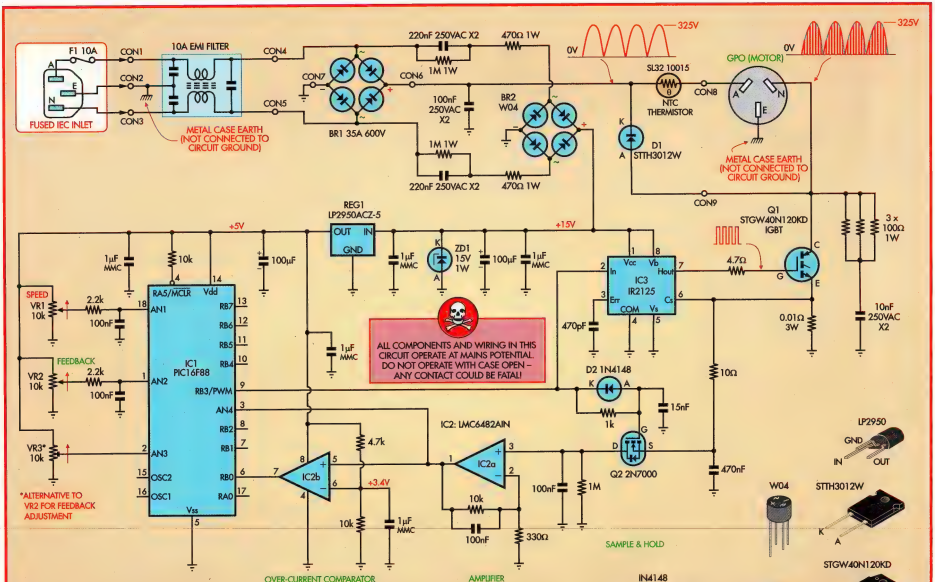
BR1 is a 35A bridge rectifier with a 400V or 600V rating. The bridge provides the circuit with the positive full-wave rectified mains voltage to power the motor. This supply is filtered using a 100nF 250VAC capacitor. The capacitor does not provide a smoothed DC supply. Instead the capacitor just filters out much of the high frequency switching noise on the supply due to the motor and also helps to reduce the voltage induced when the IGBT is switched off and D1 becomes forward biased.

A separate supply arrangement is used for the low voltage circuitry. Instead of just using high wattage resistors to limit current to a zener diode, we use a capacitor-coupled separate bridge rectifier in order to reduce power and more importantly heat dissipation inside the controller case.

The second rectifier (BR2) is fed via two 220nF capacitors and series 470Ω resistors.

The 220nF capacitors are used to provide an impedance limited current to the 15V zener diode, ZD1. For 50Hz, the impedance of each 220nF capacitor is 14.5kΩ . This, plus the 470Ω limits the current through ZD1. A 100µF capacitor across the resulting 15V supply smooths the voltage to a near-constant value.

The 470Ω resistors in series with



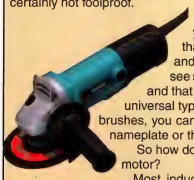
SC 10A 230VAC INTELLIGENT SPEED CONTROLLER

Fig.8: the complete circuit diagram. Note the warning – it is not safe to work on an open case when connected to the 230V AC mains!

What motors can – *and cannot* – be controlled?

We've noted elsewhere in this article that this controller suits the vast majority of power tools and appliances (which use universal motors – series-wound motors with brushes). Incidentally, they're called universal motors because they can operate on both AC and DC.

But how do you make sure that your power tool or appliance is a universal motor and not an induction motor? As we also said before, induction motors **must not be used** with this speed controller. One clue is that most universal motors are quite noisy compared to induction motors. However, this is only a guide and it's certainly not foolproof.



In many power tools you can easily identify that the motor has brushes and a commutator and you see sparking from the brushes and that shows that the motor is a universal type. But if you can't see the brushes, you can also get a clue from the nameplate or the instruction booklet.

So how do you identify an induction motor?

Most induction motors used in domestic appliances will be 2-pole or 4-pole and always operate at a fixed speed, which is typically 2850 rpm for a 2-pole or 1440 rpm for a 4-pole unit. The speed will be on the nameplate. Bench grinders typically use 2-pole induction motors.

Controlling induction motors

If you do need to control this type of motor use the 1.5kW Induction Motor Controller published in April and May 2012. Note that there are important modifications published in December 2012.

And a reminder:

You *cannot* control the speed of any universal motor which already has an electronic speec control built in, whether part of the trigger mechanism or with a separate speed dial.

This does not include tools such as electric drills which have a two-position mechanical speed switch. You can use our speed controller with the mechanical switch set to either fast or slow.

the 220nF capacitors are there to limit surge current when power is first applied to the circuit. The surge current could be high should power be switched on at the peak voltage of the mains waveform.

1MΩ resistors across the capacitors are there to discharge any stored voltage when the power is switched off.

Without these, the capacitor could have high voltage stored ready to provide an electric shock to anyone touching the capacitor when say for example, trouble shooting the circuit (even when 230V AC power is disconnected).

The 15V supply powers the IGBT driver IC3 directly, while a low-power 5V regulator derived from the 15V line supplies both IC1 and IC2. The 100µF and 1µF capacitors at the regulator's output and input ensure the regulator remains stable and that it can provide transient current without losing regulation.

IC3 is a dedicated Mosfet (or IGBT) driver used as a low-side driver where the output produces a 15V gate drive with respect to the circuit ground.

Apart from providing gate drive for the IGBT, IC3 also protects the IGBT. It does this in several ways. Firstly, the gate drive is a high current pulse to minimise the time that the IGBT is in its unsaturated state to minimise power dissipation.

Secondly, current is monitored across a 0.01Ω resistance between the emitter and the circuit ground. Whenever the voltage across this resistor rises above 230mV, representing a 23A current, the IGBT will be current-limited.

Current limiting is done by reducing the gate drive output voltage to maintain the 23A. This limiting occurs within 500ns of the over current and this is well within the 10µs required for the IGBT to be protected.

Thirdly, under-voltage protection provided by IC3 prevents any gate drive if the supply is below about 8V.

Note that while IC3 is powered from 15V, the input at pin 2 can be as low as 3.3V logic level. In our circuit a 0V to 5V signal is applied to IC3 from the PWM output of the IC1 microcontroller.

WARNING!

This is NOT a project for the inexperienced. Do not attempt to build it unless you are familiar with working with high voltage circuits.

IC2a also monitors the current across the 0.01Ω shunt via a 10Ω and 470nF low-pass filter and Mosfet Q2 is used as a sample and hold buffer. Q2 is switched on when the PWM signal being applied to its gate is high. The Mosfet then conducts and passes the voltage that's across the 470nF capacitor through to IC2a's pin 3 input.

When the PWM signal goes low, the Mosfet is off and so the sampled voltage is stored in the 100nF capacitor.

The 15nF capacitor at the gate of Q2, in conjunction with the 1kΩ gate resistor, slows down the switch-on speed of Q2. Diode D2 switches off the Mosfet more quickly when the PWM goes low.

The slow switching of Q2 is needed to reduce voltage feed-through from the gate to the drain and source. Feed-through occurs each time the gate is switched and the sudden voltage change is capacitively coupled to the drain and source.

This effect is minimised by reducing the switch on rate and also having a

low impedance source to the Mosfet. Low impedance is ensured using the 0.01Ω shunt, the 10Ω series resistor and 470μF capacitor.

Note that internal to Q2 is an intrinsic diode that allows conduction of current from the source to the drain. While Q2 could be connected in this circuit with the drain and source reversed, connecting this way would allow the 100nF capacitor at pin 3 of IC2a to discharge via the diode, when the shunt resistance voltage is lower than the 100nF capacitor's voltage.

IC2a amplifies the sampled voltage by about 31. The resulting voltage is read by IC1 via its AN4 input. IC1 effectively averages the voltage at AN4 over a 10ms period so as to capture a full half-wave portion of the mains cycle for current measurement.

The averaged current measurement is multiplied by the feedback setting of VR2 (which can be regarded as optional) or VR3. This multiplication value is then used to apply PWM adjustment for maintaining motor speed.

IC1 determines if VR2 is connected at each power up. If it is not, monitoring is redirected to VR3. Initially, AN2 is configured as an output that is set low (0V). Then AN2 is reconfigured as an analog input and the voltage level is measured.

If the level is much higher than 0V then VR2 must be connected to be able to change the level. If the level is essentially unchanged, the pin is configured as an output again but this time the output is set high (5V).

Then AN2 is set as an input and the level measured. If it remains high, then the input is open. If the input is at a lower level, then VR2 must be connected.

If VR2 is not detected, pin 1 is set as a low output and VR3 is used as the feedback input. The 2.2kΩ resistor in series is there to prevent the output being shorted during testing. The 100nF capacitor is to hold voltage during testing.

The 2.2kΩ resistor and 100nF capacitor are also included to filter out noise from associated mains wiring that could be coupled in through the potentiometer's wiper wiring. The same filtering is also included for potentiometer VR1.

Over-current

IC2b compares the voltage from IC2a's output (pin1) against a reference set at 3.4V by the 4.7kΩ and 10kΩ resistors connected across the 5V supply. The output (pin 7) goes high when IC2a output is higher than 3.4V.

Output from IC2b is ignored by IC1 unless the averaged current as detected at the AN4 input exceeds 15A. IC1 then begins to reduce the duty cycle of the PWM drive until the comparator output switches low.

Physical details

The motor speed controller is housed in a rugged diecast aluminium case, and has separate rotary speed and adjustable feedback controls.

The controller plugs into the mains via a standard IEC mains lead, while the motorised appliance plugs into a switched mains socket on the controller's case lid.

Next month:

That completes the technical description of our new Super-Smooth Full Range Universal Motor Speed Controller. We're sure you'll agree that this one really delivers the goods.

In our next issue, we'll get into the exciting part: building it! SC

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PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13) 10A 230V Motor Speed Controller (Feb14)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13)
PIC16F88	Garbage Reminder (Jan13), Bellbird (Dec13)
PIC16LF88-I/P	LED Ladybird (Apr13)
PIC16LF88-I/SO	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10)
PIC16F877A-I/P	Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12)
PIC32MX250F128B-I/SP	GPS Tracker (Nov13)
PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ64MC802-E/P	Induction Motor Speed Controller (revised) (Aug13)
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(contains PCB (04108111), programmed PIC micro, MMA8451Q accelerometer chip and 4 Mosfets)

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(contains PCB (04108111), programmed PIC micro, MMA8451Q accelerometer chip and 4 Mosfets)

CLASSIC DAC Semi kit (Feb-May13) **$45.00**
Includes the new hard-to-get SMD ICs: CS8416-CZZ, CS4398-CZZ and PLL7108DBQ plus an accurate 27MHz crystal and ten 3mm blue LEDs with diffused lenses

"LUMP IN COAX" MINI MIXER SMD parts kit: (Jun13) **$20.00**
Includes: 2 x OPA4348ID, 1 x BQ2057SN, 2 x DMP2215L, 1 x BAT54S, 1 x 0.22Ω shunt

LF-HF UP-CONVERTER SMD parts kit: (Jun13) **$15.00**
Includes: FXO-HC536R-125 and SA602AD and all SMD passive components

ISL9V5036P3 IGBT (Nov/Dec12) **$10.00**
As used in high energy ignition and Jacob's Ladder (Feb13)

2.5GHz Frequency Counter *(Dec12/Jan13)* **LED Kit:** 3 x 4-digit blue LED displays **$15.00**
MMC & Choke Kit: ERA-2SM+ Wideband MMC and ADCH-80+ Wideband Choke **$15.00**

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As used in a variety of Scope Cal+ Projects (Pack of 2)

ZXCT1009 Current Shunt Monitor IC *(Oct12)* **$5.00**
As used in DCC Reverse Loop Controller/Block Switch (Pack of 2)

LF-HF Up-converter Omron G5V-1 5V SPDT 5V relay *(June13)* **$2.00**

SMD parts for SIDRADIO *(Oct13)* **$20.00**
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GPS Tracker *(Nov13)* **$5.00**
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STEREO AUDIO DELAY *(Nov13)* **$20.00**
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JST CONNECTOR LEAD 3-WAY *(Jan12)* **$4.50**

JST CONNECTOR LEAD 2-WAY *(Jan12)* **$3.45**

RADIO & HOBBIES ON DVD-ROM (Needs PC & reader to play!) *n/a* **$62.00**

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PRINTED CIRCUIT BOARDS

NOTE: These listings are for the PCB only – *not a full kit.* If you want a kit, contact the kit suppliers advertising in this issue.
Prices in GREEN are lower prices: buy now while stocks last!

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
AM RADIO TRANSMITTER	JAN 1993	06112921	$25.00
CHAMP: SINGLE CHIP AUDIO AMPLIFIER	FEB 1994	01102941	$5.00
PRECHAMP: 2-TRANSISTOR PREAMPLIER	JUL 1994	01107941	$5.00
HEAT CONTROLLER	JULY 1998	10307981	$10.00
MINIMITTER FM STEREO TRANSMITTER	APR 2001	06104011	$25.00
MICROMITTER FM STEREO TRANSMITTER	DEC 2002	06112021	$10.00
SMART SLAVE FLASH TRIGGER	JUL 2003	13107031	$10.00
12AX7 VALVE AUDIO PREAMPLIFIER	NOV 2003	01111031	$25.00
POOR MAN'S METAL LOCATOR	MAY 2004	04105041	$10.00
BALANCED MICROPHONE PREAMP	AUG 2004	01108041	$25.00
LITTLE JIM AM TRANSMITTER	JAN 2006	06101062	$25.00
POCKET TENS UNIT	JAN 2006	11101061	$25.00
STUDIO SERIES RC MODULE	APRIL 2006	01104061	$25.00
ULTRASONIC EAVESDROPPER	AUG 2006	01206061	$25.00
RIAA PREAMPLIFIER	AUG 2006	01106061	$25.00
GPS FREQUENCY REFERENCE (A) (IMPROVED)	MAR 2007	04103073	$30.00
GPS FREQUENCY REFERENCE DISPLAY (B)	MAR 2007	04103072	$20.00
KNOCK DETECTOR	JUNE 2007	05106071	$25.00
SPEAKER PROTECTION AND MUTING MODULE	JULY 2007	01207071	$20.00
CDI MODULE SMALL PETROL MOTORS	MAY 2008	05105081	$15.00
LED/LAMP FLASHER	SEP 2008	11009081	$10.00
12V SPEED CONTROLLER/DIMMER (Use Hot Wire Cutter PCB from Dec 2010 [18112101])			
USB-SENSING MAINS POWER SWITCH	JAN 2009	10101091	$45.00
DIGITAL AUDIO MILLIVOLTMETER	MAR 2009	04103091	$35.00
INTELLIGENT REMOTE-CONTROLLED DIMMER	APR 2009	10104091	$50.00
INPUT ATTENUATOR FOR DIG. AUDIO M'VOLTMETER	MAY 2009	04205091	$10.00
6-DIGIT GPS CLOCK	MAY 2009	04105091	$30.00
6-DIGIT GPS CLOCK DRIVER	JUNE 2009	07106091	$20.00
UHF ROLLING CODE TX	AUG 2009	15008091	$10.00
UHF ROLLING CODE RECEIVER	AUG 2009	15008092	$45.00
6-DIGIT GPS CLOCK AUTODIM ADD-ON	SEPT 2009	04208091	$5.00
STEREO DAC BALANCED OUTPUT BOARD	JAN 2010	01101101	$25.00
DIGITAL INSULATION METER	JUN 2010	04106101	$25.00
ELECTROLYTIC CAPACITOR REFORMER	AUG 2010	04108101	$40.00
ULTRASONIC ANTI-FOULING FOR BOATS	SEP 2010	04109101	$25.00
HEARING LOOP RECEIVER	SEP 2010	01209101	$25.00
S/PDIF/COAX TO TOSLINK CONVERTER	OCT 2010	01210101	$10.00
TOSLINK TO S/PDIF/COAX CONVERTER	OCT 2010	01210102	$10.00
DIGITAL LIGHTING CONTROLLER SLAVE UNIT	OCT 2010	16110102	$45.00
HEARING LOOP TESTER/LEVEL METER	NOV 2010	01111101	$25.00
UNIVERSAL USB DATA LOGGER	DEC 2010	04112101	$25.00
HOT WIRE CUTTER CONTROLLER	DEC 2010	18112101	$10.00
433MHZ SNIFFER	JAN 2011	06101111	$10.00
CRANIAL ELECTRICAL STIMULATION	JAN 2011	99101111	$25.00
HEARING LOOP SIGNAL CONDITIONER	JAN 2011	01101111	$25.00
LED DAZZLER	FEB 2011	16102111	$20.00
12/24V 3-STAGE MPPT SOLAR CHARGER	FEB 2011	14102111	$35.00
SIMPLE CHEAP 433MHZ LOCATOR	FEB 2011	06102111	$5.00
THE MAXIMITE	MAR 2011	06103111	$15.00
UNIVERSAL VOLTAGE REGULATOR	MAR 2011	18103111	$10.00
12V 20-120W SOLAR PANEL SIMULATOR	MAR 2011	04103111	$10.00
MICROPHONE NECK LOOP COUPLER	MAR 2011	01209101	$25.00
PORTABLE STEREO HEADPHONE AMP	APRIL 2011	01104111	$10.00
CHEAP 100V SPEAKER/LINE CHECKER	APRIL 2011	04104111	$10.00
PROJECTOR SPEED CONTROLLER	APRIL 2011	13104111	$10.00
SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00
100W DC-DC CONVERTER	MAY 2011	11105111	$15.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00
20A 12/24V DC MOTOR SPEED CONTROLLER MK2	JUNE 2011	11106111	$20.00
USB STEREO RECORD/PLAYBACK	JUNE 2011	07106111	$20.00
VERSATIMER/SWITCH	JUNE 2011	19106111	$25.00
USB BREAKOUT BOX	JUNE 2011	04106111	$10.00
ULTRA-LD MK3 200W AMP MODULE	JULY 2011	01107111	$25.00
PORTABLE LIGHTNING DETECTOR	JULY 2011	04107111	$20.00
RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per se
VOX	JULY 2011	01207111	$20.00
ELECTRONIC STETHOSCOPE	AUG 2011	01108111	$10.00
DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$10.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$20.00
ULTRA-LD MK2 AMPLIFIER UPGRADE	SEP 2011	01209111	$5.00
ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	$20.00
GPS FREQUENCY REFERENCE (IMPROVED)	SEP 2011	04103073	$30.00
HEARING LOOP RECEIVER/NECK COUPLER	SEP 2011	01209101	$10.00
DIGITAL LIGHTING CONTROLLER LED SLAVE	OCT 2011	16110111	$30.00
USB MIDIMATE	OCT 2011	23110111	$25.00
QUIZZICAL QUIZ GAME	OCT 2011	08110111	$25.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$30.00
ULTRA-LD MK3 INPUT SWITCHING MODULE	NOV 2011	01111112	$20.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	04111211	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$25.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201112	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201112P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101112/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMITEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMITEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMITEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	13105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CONDUCTIVE/FREAKY FROG	JUNE 2012	08106121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$15.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110122	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102132	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-465MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIE	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp [Sept11])	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS	DEC 2013	01111131-3	$35.00/set
(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])			
LED PARTY STROBE (also for Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
BASS EXTENDER Mk2	JAN 2014	01112131	$15.00
L'IL PULSER Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$15.00

Stereo Echo & Reverb Unit

By NICHOLAS VINEN

Based on the Stereo Audio Delay featured in the November 2013 issue, this modified unit can be used to provide adjustable echo or reverberation for recording or public address (PA) work. By using revised software and slight changes to the circuitry, we show how the same hardware can provide these different functions. We'll also describe some extra features that can be useful in either mode.

IN ESSENCE, the Stereo Audio Delay described in the November 2013 issue consists of an analog-to-digital converter (ADC) and a digital-to-analog converter (DAC), with a PIC32 microcontroller processing the digital audio stream between the two. This microcontroller has a large internal RAM (128KB) which, together with an optional external 1MB SRAM chip, can be used for buffering and manipulating the audio data stream.

By controlling how much of this memory is used for buffering, the PIC32 can delay the audio by a variable amount. But it can also process the audio data and perform some sort of filtering, for example.

In fact, providing an adjustable echo effect requires only a small amount of additional processing compared to what's needed for audio delay; we simply need to mix a proportion of the delayed audio back into the input signal.

This simulates a real (acoustic) echo, whereby sound waves travel a significant distance, resulting in a time delay (since sound travels at around 340m/s at sea level). The attenuation of expanding sound waves travelling through a significant volume of air, along with the losses inherent in reflections off less-than-perfect surfaces, result in the volume of the echo being lower than that of the original sound.

The echo itself has an echo, so that a single transient sound has a number of echoes, spaced equally apart in time and with a decaying sound level. This aspect of echo is also simulated by the above simple method. That's because by mixing an attenuated version of the delayed signal back into the input signal, that echo itself is delayed and attenuated, and so on ad infinitum until the volume has decayed so far that it is no longer audible (see Fig.1).

Fig.3 shows the circuit of the Stereo Echo/Reverberation Unit. It's basically just the Stereo Audio Delay described in November 2013 with various optional extra bits added on (plus the revised software for the micro). Provision was made on the original PCB to accept these extra bits, so you don't have to start from scratch with a new board. Instead, it's just a matter of building the PCB has originally described and adding the extra parts.

Enabling echo mode

As it stands, the November 2013

The new unit is built on the same PCB as the Stereo Audio Delay Unit described in November 2013. It's just a matter of adding a few extra parts and using revised software.

Features & Specifications

- Adjustable stereo echo or reverb with interval of 0-640ms
- Echo delay and attenuation adjustable via front panel knobs
- Optional defeat switch connection for foot pedal; can configured as normally on or normally off
- THD+N: <0.03% (typically <0.02%), 20Hz-20kHz (20Hz-22kHz bandwidth)
- Signal-to-noise ratio: typically >76dB (line inputs/outputs)
- Optimal line input signal range: 0.5-2V RMS
- Line output signal: 1V RMS
- Input impedance: 4-6kΩ (line input), 8.2kΩ (microphone input)
- Power supply: 7.5-12V DC or 3.8-6.5V DC, depending on configuration; current drain 60-80mA
- Microphone input: 20-50mV input for full scale output, signal-to-noise ratio 67dB.
- Headphone output: drives 8-32Ω at up to 50mW, THD+N 0.05% @ 10mW/32Ω, volume adjustable in 1dB steps

unit can be switched from delay mode to echo mode by placing a shorting jumper across pins 3 & 4 of CON7, the ICSP header.

When the unit is powered up, the software briefly attempts to pull pin 4 high and checks its state. With no jumper plugged into CON7, this pin will be sensed as high and so the unit will perform its default task which is to provide audio delay. However if pins 3 & 4 are shorted, pin 4 will remain low despite the pull-up and so echo mode is activated.

As explained last November, pins 4 & 5 of CON7 are normally PWM signals generated by the microcontroller which can be measured in order to determine the configured delay in milliseconds. But if the software detects that pin 4 is shorted to ground at start-up, it disables this PWM output in order to avoid driving this short circuit. You can measure the echo delay at pin 5; in echo mode, the unit will only operate in stereo so there is only one delay to measure.

The other reason that echo will only operate in stereo is that in this mode, VR1 (or VR3) is used to set the echo delay while VR2 (or VR4), if present, sets the echo attenuation. If neither VR2 nor VR4 are installed, then the attenuation is set to 12dB.

As with the regular delay mode, a delay of up to 600ms is available without the external SRAM chip IC3 fitted or up to six seconds with IC3 in place. But 600ms is quite a long delay and should be sufficient for most echo effects.

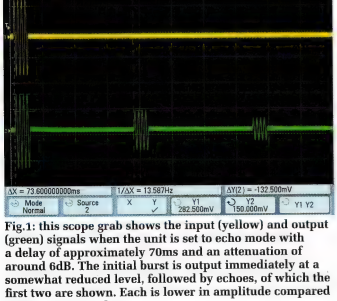


Fig.1: this scope grab shows the input (yellow) and output (green) signals when the unit is set to echo mode with a delay of approximately 70ms and an attenuation of around 6dB. The initial burst is output immediately at a somewhat reduced level, followed by echoes, of which the first two are shown. Each is lower in amplitude compared to the previous echo.

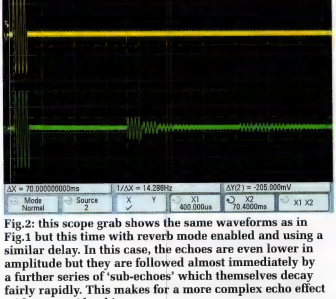
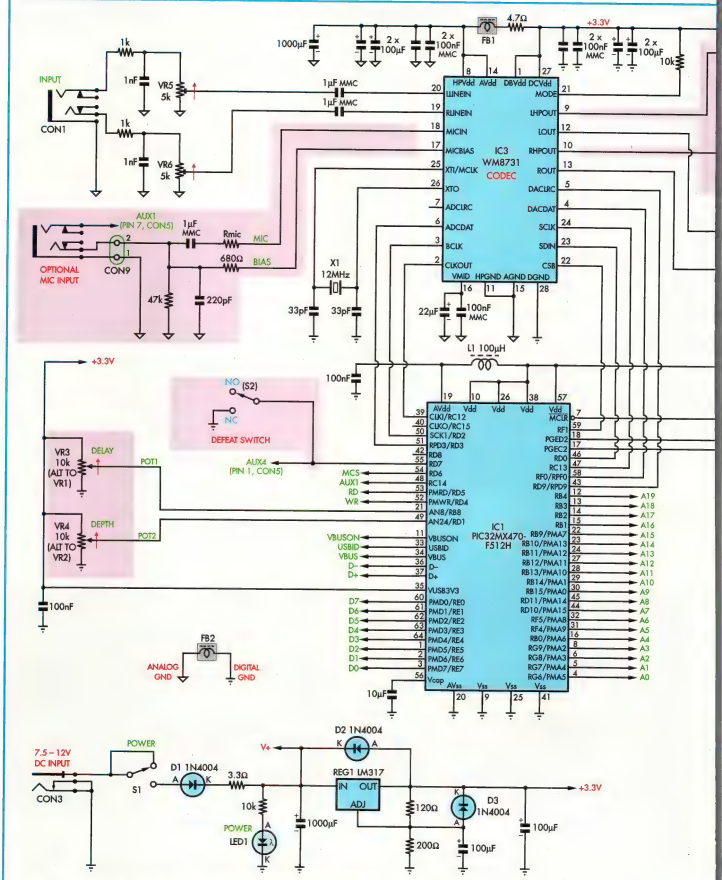


Fig.2: this scope grab shows the same waveforms as in Fig.1 but this time with reverb mode enabled and using a similar delay. In this case, the echoes are even lower in amplitude but they are followed almost immediately by a further series of 'sub-echoes' which themselves decay fairly rapidly. This makes for a more complex echo effect with greater 'depth'.



STEREO ECHO / REVERBERATION UNIT

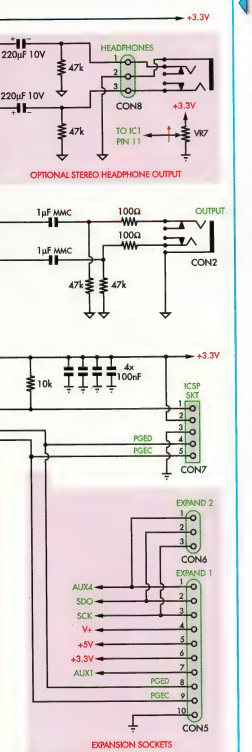


Fig.3: the Stereo Echo/Reverberation Unit circuit. It's basically the same as the Stereo Audio Delay Unit published in November 2013 but with the added circuitry highlighted with a red background (plus revised software for IC1).

So really it's just a matter of building the unit as described in the November 2013 issue, with VR3 & VR4 fitted, installing the jumper on pins 3 & 4 of CON7, powering it up and then adjusting the knobs until you get an echo effect that you are happy with.

We have produced new front and rear panel labels (Fig.5) with positions marked to drill the extra holes for VR3 & VR4. Positions are also marked for a headphone volume control and output socket which we'll explain later. These panels can either be copied or downloaded from the SILICON CHIP website.

Defeat switch

If you are building this as an echo effects unit for musical performances, you will need a way to switch it on and off. To shut off the echo, we simply pull input RD7 (pin 55) of IC1 low; it is internally biased high by a weak current source. This pin is labelled as AUX4 on the circuit diagram (Fig.3) and is wired to a pad on the PCB at the top, near the middle (see Fig.4).

These pads are designed to suit an SPDT right-angle pushbutton switch (eg, Altronics S1498) but for musical performances, having a button on the unit isn't very practical. Instead, we suggest fitting a 3.5mm phono jack socket to the rear panel of the unit and wiring it to the two switch connections on the PCB via a 3-way header (ie, middle-pin unused). A foot switch can then be plugged in via a length of cable fitted with a 3.5mm jack plug.

Foot switches generally have a double-throw switch, with three terminals: COM, NC (normally closed) and NO (normally open). If you wire the plug tip and sleeve to the COM and NC terminals, pushing on the foot switch will enable the echo effect and it will stop when you lift your foot off. This is the most logical way to wire it. However, you could also wire the plug to the COM and NO terminals and then the echo effect will be disabled by pressing on the switch and re-enabled by lifting off.

The wiring arrangement for the foot switch socket is shown in Fig.4, along with some extra wiring we'll describe later. This is also shown on the circuit diagram (Fig.3).

Our revised rear panel artwork includes a hole position marked for the foot switch socket and an associated label. Note that the position shown has been chosen to avoid interference between the panel-mounted socket and trimpots VR5 & VR6.

Reverb

Echo is basically a simple form of reverb (or reverberation).

In a space such as a concert hall, there won't be just a single echo duration for sounds originating on the stage and being heard by people sitting in the audience. Instead, there will be many different paths that the sound can take. The direct path is the shortest and gives the least attenuation but sounds also bounce off various surfaces before reaching the listener and each path will have its own delay and (probably frequency-dependent) attenuation.

Professional reverberation units can provide many different options, to simulate halls of various different configurations. In this unit, we've stuck with a simple approach which gives a more complex (and audibly distinct) response than a simple echo without being terribly processor intensive or having a lot of parameters to tweak.

Essentially, to obtain the reverb effect, we add an echo with a short time delay to the sound, then take the resulting sound and process that with a much longer delay. This simulates a large space where there are multiple paths for the sound to bounce around, each with a slightly different length, and thus the echoes arrive at slightly different times.

To enable reverb mode, pins 3 & 5 of CON7 must be shorted. Pin 4 should be left open and can be used to measure the set delay.

Note that since pins 3 & 5 aren't adjacent, you can't use a shorting block to do this. The trick is to use a 3-pin female header and solder a short length of wire between the two outside pins and then plug this into CON7. Of course, you could solder a wire directly to pins 3 & 5 of CON7 but then it's harder to disconnect.

As with echo, reverb mode only operates in stereo and the adjustments are

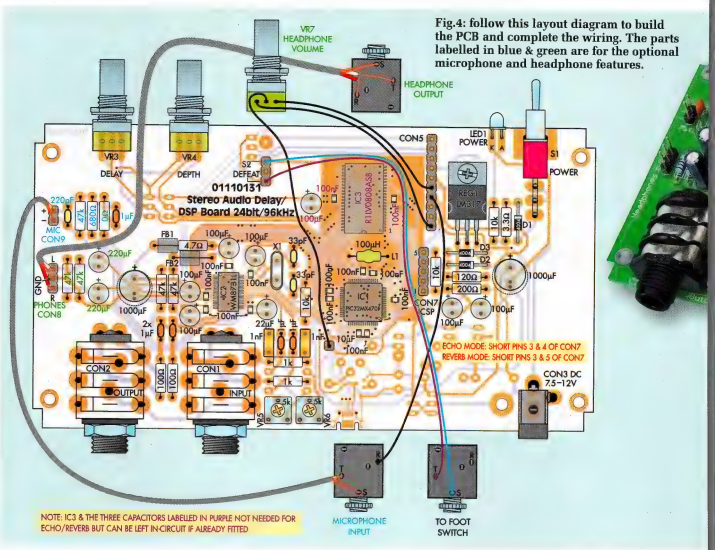


Fig.4: follow this layout diagram to build the PCB and complete the wiring. The parts labelled in blue & green are for the optional microphone and headphone features.

identical. The long delay is adjusted as for echo mode while the short delay is automatically set to be 1/8th as long. So if you select a 200ms long delay, the short delay will be 25ms.

The same attenuation setting is used for both short and long delays and as with echo, this can be adjusted with VR3/VR4; otherwise it's set to 12dB by default.

Echo/reverb switching

An SPDT switch can be used if you want to be able to switch between echo and reverb modes. To do this, first connect its common terminal to pin 3 of CON7 (or another ground connection point) via a series 1kΩ resistor. The two remaining switch terminals then go to pins 4 & 5 of CON7.

The 1kΩ resistor is necessary to prevent a dead short to the PWM output if switching is done while the unit is on. Note that since the unit only checks the state of these pins at power-up, you would then have to switch the unit off and then on again to complete the changeover.

Headphone & mic support

In the November 2013 issue, the following pins of CODEC IC2 were unconnected: LHPOUT, RHPOUT, MICIN and MICBIAS. These pins can be used for a microphone input and/or a stereo headphone output – see Fig.3.

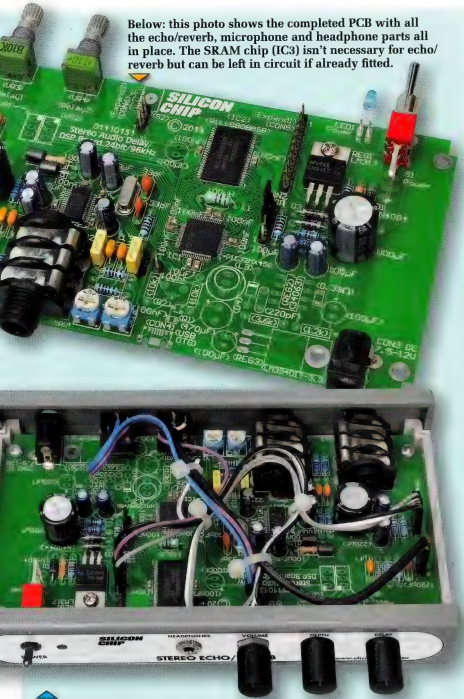
This allows you to take advantage of the headphone amplifier with digital volume control and the microphone amplifier with electret bias built into the IC. When a microphone is connected, the microcontroller detects this and automatically switches from sampling the line inputs to sampling the microphone input.

By the way, the microphone amplifier in IC2 is quite a bit noisier than a good external microphone amplifier (which could be connected to the line inputs) but you may find it suitable for some uses (see the spec. panel).

To add a headphone output, it's just a matter of installing the additional parts labelled in green on the PCB layout (Fig.4). This consists of two 220µF DC-blocking electrolytic capacitors and their associated 47kΩ resistors, plus 3-pin header CON8. A panel-mounted 3.5mm phono socket is then wired back to this header. We've shown a 2-core shielded cable for this connection but it doesn't really need to be shielded.

You also need to wire up an extra potentiometer (VR7) to allow the volume to be controlled. This volume pot is also mounted on the front panel, next to the other two pots, and wired to 10-way pin header CON5 (which must also be installed) and to a single pin soldered to a pad just below and to the left of IC1.

By wiring the pot this way, we're connecting in a virtually the same manner as VR3 and VR4, ie, across the 3.3V



Below: this photo shows the completed PCB with all the echo/reverb, microphone and headphone parts all in place. The SRAM chip (IC3) isn't necessary for echo/reverb but can be left in circuit if already fitted.

Above: the fully-assembled PCB mounted inside the case and with the wiring completed. Use cable ties to secure the wiring as shown.

supply rail. The wiper is connected to pin 11 of IC1 via the single pin connection shown, which is the only remaining free ADC-capable input of IC1. This connection is also indicated on the circuit diagram (Fig.3).

The revised software (0111013B.hex) for microcontroller IC1 automatically detects when this pot is present and if it is, constantly samples the voltage at pin 11. If this voltage changes, IC1 sends a command to CODEC IC2 to adjust the headphone output volume.

Microphone input

The extra circuitry required to hook up a microphone is also quite simple. As shown on Fig.3, the signal from the microphone is fed in via a 1µF non-polarised capacitor. The resistor labelled "Rmic" is normally 0Ω which sets the microphone gain to 26dB. However, if this is too much gain, you can reduce it somewhat by using a higher-value resistor.

A 39kΩ resistor for Rmic will reduce the gain to 20dB, while a 15kΩ resistor will give a gain of approximately 23dB. For maximum gain, if you don't have a 0Ω resistor, use a wire link instead.

If using an unpowered electret microphone, it will require a small bias current to operate. In this case, the 680Ω resistor should be fitted and the bias current will come from IC2's MICBIAS output which is enabled by default when a microphone is plugged in. The 47kΩ resistor to ground provides 0V DC bias for the microphone when there is no bias current, while a 220pF capacitor provides a small amount of RF filtering.

The micro detects when a microphone is plugged in by monitoring input pin RC14 (pin 48) which is connected to a track labelled "AUX1" via pin 7 of 10-way pin header CON5. As explained previously, this header

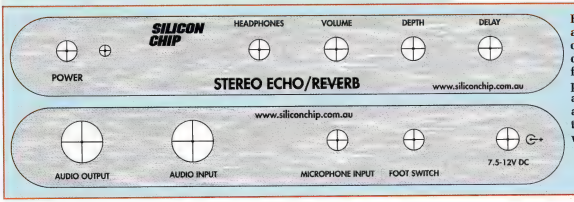


Fig.5: these two artworks can be copied and used as drilling templates for the front & rear panels. They can also be downloaded as a PDF file from the SILICON CHIP website.

The additional 3.5mm microphone input and foot switch jack sockets are mounted on the rear panel. A 7.5-12V DC plugpack powers the unit.

Parts List

1 double-sided PCB, coded 01110131, 148 x 80mm
1 ABS plastic instrument case, 155 x 86 x 30mm (Altronics H0377)
1 set front and rear panel labels
4 No.4 x 6mm self-tapping screws
1 12MHz HC-49 crystal (X1)
1 100µH axial RF inductor (L1)
1 10kΩ multi-turn vertical trimpot (VR1) OR 1 x 10kΩ 9mm horizontal potentiometer (VR3)
2 5kΩ horizontal mini trimpots (VR5,VR6)
2 6.35mm PCB-mount stereo switched jack sockets (CON1,CON2) (Jaycar PS0195, Altronics P0099 or P0073)
1 5-way pin header, 2.54mm pitch (CON7)
1 PCB-mount SPDT right-angle toggle switch (Altronics S1320)
1 DC plugpack, 7.5-12V, 100mA+
2 4mm ferrite suppression beads
1 PCB-mount switched DC socket to suit plugpack
1 M3 x 6mm machine screw and nut

Semiconductors

1 PIC32MX470F512H-I/PT 32-bit microcontroller programmed with 0111013B.hex (IC1) (available from SILICON CHIP Online Shop)
1 WM8731SEDS or TLV320AIC23BIPW 24-bit 96kHz stereo CODEC (IC2) (element14 1776264)
1 LM317T adjustable regulator (REG1)
1 3mm blue LED (LED1)
3 1N4004 diodes (D1-D3)

Capacitors

2 1000µF 25V electrolytic
6 100µF 16V electrolytic
1 22µF 16V electrolytic
1 10µF 6.3V 0805 SMD ceramic
4 1µF 50V monolithic ceramic
11 100nF 6.3V 0805 SMD ceramic
2 1nF MKT
2 33pF ceramic disc

Resistors (0.25W, 1%)

2 47kΩ	1 120Ω
3 10kΩ	2 100Ω
2 1kΩ	1 4.7Ω 0.5W 5%
1 200Ω	1 3.3Ω 0.5W 5%

Add-on Features

For echo/reverb:

1 3.5mm panel-mount stereo jack socket (eg, Jaycar PS0133, Altronics P0092)
1 3-way pin header
1 jumper shunt
1 100mm length 2-strand ribbon cable
1 2-core cable with 3.5mm jack plug at one end (length as required)
1 foot switch

For headphone output:

1 3.5mm panel-mount stereo jack socket (eg, Jaycar PS0133, Altronics P0092)
1 10kΩ 9mm panel-mount linear potentiometer (Jaycar RP8510)
1 small knob to suit
2 220µF 10V electrolytic capacitors
2 47kΩ 0.25W resistors
1 100mm length 2-core shielded cable or 3-strand ribbon cable
1 100mm length 3-strand ribbon cable
1 14-way (or more) snappable pin header

For microphone input:

1 3.5mm panel-mount stereo jack socket (eg, Jaycar PS0133, Altronics P0092)
1 1µF multi-layer ceramic capacitor
1 220pF ceramic capacitor
1 47kΩ 0.25W resistor
1 680Ω 0.25W resistor
1 2-way pin header
1 100mm length shielded cable
1 100mm length ribbon cable strand or light-duty hookup wire

For low-voltage supply:

1 LM3940IT-3.3 or TS2940-3.3 low-dropout 3.3V regulator (REG2) (Jaycar ZV1565, Altronics Z0599)
1 1N5819 1A Schottky diode (D1)
1 470µF 10V electrolytic capacitor
1 100µF 16V electrolytic capacitor
Delete REG1 & associated parts

Note: microcontroller IC1 must be programmed with revised software (ie, 0111013B.hex) for echo/reverb and the other add-on features to work.

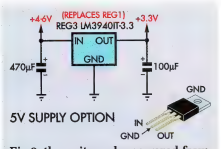


Fig.6: the unit can be powered from a 4-6V DC supply by replacing REG1 with an LM3940IT-3.3 low-dropout regulator as shown here.

was intended at the time for future expansion. The micro enables a weak internal pull-up on this pin which is connected to the ring terminal of the microphone input.

Since the microphone input is mono, when a mono plug is inserted, this will short the ring and sleeve terminals. The sleeve is connected to ground and so AUX1 is pulled low. The micro mutes the input for half a second when this input changes state. If, after this period, the input is low then the microphone input is selected. Otherwise, the line input is used.

Thus if a microphone is plugged in, the unit automatically switches to that as the signal source and when it is removed, it automatically switches back to the line inputs. Because the microphone input is mono, the same signal is sent to both audio output channels.

5V/battery operation

The power supply for the unit is based on a series polarity protection diode (D1) and an LM317 regulator (REG1) configured to provide a 3.3V output. This requires an input voltage of 6V or more (preferably 7.5-12V) to ensure proper output regulation.

However, as stated in November 2013, it's possible to reconfigure the unit to run from 3.8-6.5V. This makes it suitable for use with USB power (4.25-5.5V), a single Li-ion or Li-Po cell, or four standard cells (alkaline or rechargeable).

This alternative power supply arrangement is shown in Fig.6 and the parts layout diagram of Fig.7. Basically, an LM3940IT-3.3 fixed low-dropout regulator (REG3) is used instead of the LM317T, along with a couple of wire links to get power to it. In addition, the 1N4004 reverse polarity protection diode (D1) is replaced with a 1N5819 Schottky diode since the latter has a much lower forward voltage.

This gives a minimum operating voltage of around 3.6V, so if you power the unit from a Li-ion or Li-Po cell, the cell will be pretty much fully discharged before the circuit ceases normal operation (in practice, it will probably operate down to at least 3.3V but without supply regulation).

Note that while this arrangement allows the unit to run off lower input voltages, damage may occur if more than 7V is applied, even briefly. So if using a plugpack with this new arrangement, **be sure to measure its actual unloaded output voltage rather than relying on its nominal rating. A 5V unregulated plugpack could easily put out more than 7V at light load.**

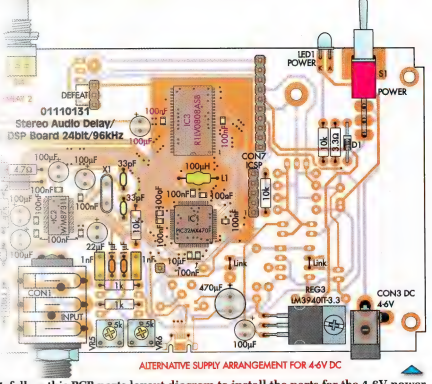


Fig.7: follow this PCB parts layout diagram to install the parts for the 4-6V power supply option. Note that D1 must be changed to a 1N5819 Schottky type.

Building it

You can take two approaches when building this Stereo Echo & Reverb Unit. The easy approach is to buy the kit for the Stereo Audio Delay Unit from Jaycar (Cat. KC-5506) and also obtain the extra parts for the features you want to add, such as the microphone input and/or the headphone output. These parts are all shown in the complete parts list included here.

Note that the PIC32 microprocessor must be programmed with the revised version of the software (ie, 0111013B.hex) in order for the echo/reverb and the other features to work. This revised software is also valid for the original Stereo Audio Delay described in November 2013 and has been forwarded to Jaycar for use in future kit runs.

The revised software can also be downloaded (free for subscribers) from the SILICON CHIP website and used to program the micro via the ICSP header. Alternatively, you can purchase a pre-programmed micro from SILICON CHIP.

Basically, it's just a matter of first building the PCB as described in the November 2013 article. You then simply add the extra parts to the PCB for the microphone and/or headphone options and complete the wiring as shown in Fig.4.

Don't forget to link the appropriate pins on CON7 to enable echo or reverb mode. Link pins 3 & 4 for echo mode (use a shorting jumper), or pins 3 & 5 for reverb mode (use a 3-way female header with the outside terminals linked).

If you want to run the unit from a 4-6V supply, then build the power supply section as shown above in Fig.7. Don't forget that diode D1 (near switch S1) must be a 1N5819 Schottky type.

Fig.5 shows the revised front and rear panels and these can be used as drilling templates for the extra holes required for the pots and the stereo jack sockets. Note that the headphone volume pot (VR7) is mounted directly on the front panel rather than on the PCB. SC

RUBIDIUM Frequency Standards

How they've shrunk in both size & cost!

Like their better known cesium-beam based cousins, rubidium-vapour frequency standards (AKA 'atomic clocks') have shrunk considerably in both size and cost since they were first developed in the early 1960s. In fact, rubidium standards have shrunk much further than the cesium type and are now down to the same size as an oven-controlled quartz oscillator or 'OCXO'. Their cost has also dropped far below that of a cesium standard, too.

By JIM ROWE

ALTHOUGH THEY didn't appear in practical form until a few years after the first cesium-beam frequency standards, rubidium-vapour standards proved to be much more suited for making smaller and more portable frequency references. This was partly due to the rapid developments in microwave technology that took place during and after World War 2, along with the dramatic developments in solid-state technology that happened at much the same time.

There was also a chicken and egg effect. When both military and commercial communications began to move into the UHF and microwave spectrum, this generated a huge market for low-cost yet highly accurate frequency standards – and manufacturers of rubidium-vapour standards were able to take advantage of this demand.

The growth in demand not only continued but almost became explosive as mobile phones first went 'cellular' and then morphed into CDMA and its related digital technologies. Of course, the development of the internet and digital data communications played a major role too, as the need for accurate frequency and timing references multiplied exponentially.

The net result of these developments is that by the year 2000, there were many hundreds of thousands of compact, low cost Rb-vapour frequency standards in use all over the world. There were also many different firms manufacturing them, such as Quartzlock in the UK (www.quartzlock.com), Stanford Research Systems in California, USA (www.thinksrs.com), Symmetricom Inc, also in California (www.symmetricom.com) and FEI Communications Inc of Mitchell Field, New York (www.freqelec.com).

Nowadays we've reached the stage where you can buy very small Rb-vapour frequency standards brand new for less than $2500. For example, the Quartzlock E10-MRX subminiature unit is currently available for $A2210 plus GST (or $2431) from Quartzlock's Australian representatives Trio Test & Measurement (www.triotest.com.au), while the Stanford Research Systems PRS10 can be ordered online from their website for $US1645 plus $US224.20 for shipping and handling.

But that ain't all, folks. A quick scout around the web – and on eBay in particular – discovered many different 'used' Rb-vapour references available for less than $US250 and as little as $US99.00 (plus postage etc). Most of

The smallest Rb-vapour standard to date: Quartzlock's E10-MRX, shown here actual size.

Above: used FE-5680A Rb-vapour standards are available on eBay from China for less than $150 including postage.

these were on offer from China and appear to be 'reclaimed' from surplus telecom gear – perhaps exported from the USA or Europe.

There were many different FE-5680A units from FEI Communications, plus a few FRK, FRS-A, FRS-C and LPRO-101 units from Symmetricom (the latest incarnation of Efratom, which became Ball and then Datum).

Because they are 'pre-loved', these very low priced Rubidium frequency references are a bit of a gamble. That's because the Rb-vapour discharge tubes used in these references have a relatively limited working lifetime – the latest generation tubes have a rated lifetime of 20 years, while the earlier generations were found to have somewhat less. So it's quite possible that at least some of the el-cheapo units were junked because their RB-vapour tubes had reached the nominal end of their working life.

But before you dismiss the idea of buying one of these 'el cheapo' frequency references, consider this: on the internet I also found some information suggesting that it's possible to 'rejuvenate' tired old Rb-vapour discharge tubes – to bring them back to almost 'as new' condition. So buying one of them might not be so risky after all.

Anyway, to cut this introductory preamble short, here's an admission: I recently purchased one of the used FE-5680A units myself, with the idea of seeing how easy it is to get going. Hopefully, I may be able to tell you more about this later in the year.

For the present though, let's have a look at how rubidium-vapour frequency references or 'atomic clocks' actually work.

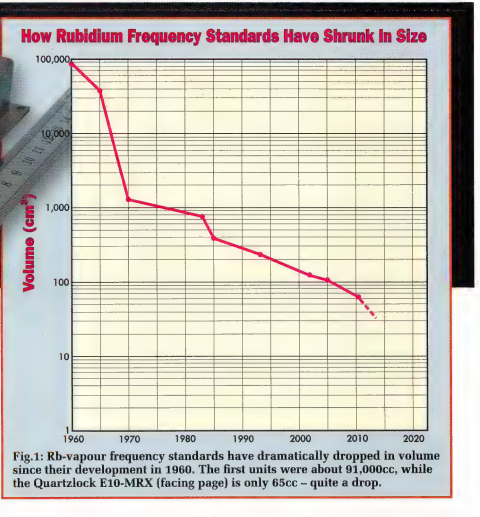


Fig.1: Rb-vapour frequency standards have dramatically dropped in volume since their development in 1960. The first units were about 91,000cc, while the Quartzlock E10-MRX (facing page) is only 65cc – quite a drop.

How they work

First of all, forget any thoughts about 'atomic clocks' (of either the Cs-beam or Rb-vapour type) having anything to do with nuclear power. They don't – not at all. While they do involve atoms of cesium or rubidium gaining or losing energy, this is purely in terms of changes in the energy levels of electrons in the outermost levels of the atoms.

There are no changes inside the nuclei of the atoms. Just electrons jumping from one energy level to another, as in normal electrical conduction. And to brush up on high school physics and chemistry, rubidium is a silvery-white metallic element in the alkali metal group. It has the atomic number 37 and an atomic mass of 85.4678. It's also highly reactive, oxidising rapidly in air or water (like sodium, potassium and cesium). Rubidium also has a very low melting point; just 39.3°C (102.74°F).

Naturally occurring rubidium is a mixture of two isotopes: Rb-85, which is very stable and Rb-87 which is slightly radioactive (with a half-life of 48.8×10^9 years). The isotopes are usually found mixed in the proportions 72.2% of Rb-85 to 27.8% of Rb-87. As the only difference between the two isotopes is the number of neutrons in their nuclei, this explains why the official atomic mass of natural Rb is given as 85.4678.

Rubidium atoms in both of these natural isotopes have only a single electron in their outermost energy levels (ie, a single valence electron). But in the unexcited or 'ground' state of both isotopes, this valence electron can occupy one of two very slightly separated energy levels – depending on the electron's spin.

The operation of Rb-vapour frequency standards takes advantage of the fact that the two 'hyperfine-split' ground state energy levels of Rb-87 atoms differ by an amount (28μeV) corresponding exactly to the amount of energy carried by a microwave photon

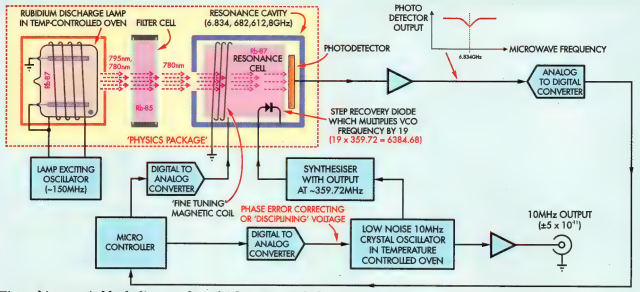


Fig.2: this generic block diagram for a fairly recent Rubidium-vapour frequency reference shows how these units work. Earlier units, like the Efratom FRK and the original FE-5680A, had an analog frequency locking loop and synthesiser but worked in much the same way.

at a frequency of 6.834,682,612,8GHz.

So if a photon of this frequency meets an Rb-87 atom where the valence electron is in the lower ground state energy level, it can 'bump' the electron into the upper level. Conversely, if the Rb-87 atom has its valence electron in the upper ground state energy level and 'relaxes' (say as the result of an applied magnetic field), it emits a photon of this frequency.

As it happens, atoms of the Rb-85 isotope also have two hyperfine-split ground state energy levels for the valence electron. However, quite fortuitously, the lower of these two energy levels in the Rb-85 isotope is almost exactly the same as the upper ground state energy level of the Rb-87 isotope. Rb-vapour frequency standards also take advantage of this coincidence, as we will see shortly.

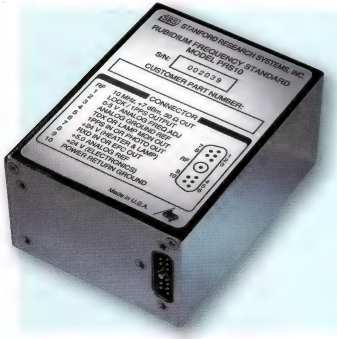
Now take a look at the block diagram of Fig.2, which shows the typical configuration inside an Rb-vapour frequency standard. At its heart is the so-called 'physics package' at upper left, which essentially functions as a very high 'Q' filter, tuned to the Rb-87 'hyperfine transition' frequency of 6.83468GHz. By having this filter as part of a feedback loop based around the low-noise 10MHz voltage controlled crystal oscillator at lower right, the frequency of the oscillator is 'disciplined' to remain at exactly 10MHz ±5 parts in 10^{-11}.

As you can see, there are two main components inside the physics package. One is the rubidium discharge lamp at the left end, while the other is the resonance cell and microwave cavity at the right end. Although a third 'filter cell' is shown between the two in Fig.2, many of the newer Rb-vapour frequency standards have a simplified configuration where the filter cell is effectively combined with the resonance cell.

The discharge lamp on the left is filled with a mixture of Rb-87 enriched vapour and a noble gas such as krypton. This gas mixture is excited by RF energy from an oscillator operating at about 150MHz, via both a pair of electrodes and a coil wound around the lamp.

As a result of this excitation, a discharge plasma is established inside the lamp and it emits light in the ruby red part of the spectrum with two peak wavelengths at 795nm and 780nm. These correspond to the valence electrons in excited Rb-87 atoms dropping from an excited energy level to one or the other of the two hyperfine split ground state levels.

The light from the discharge lamp



Left: the PRS10 Rb-vapour frequency standard from Stanford Research Systems. It measures just 50 x 75 x 102mm and can be purchased (new) for about $2200 including freight.

then passes through the filter cell, which contains Rb-85 vapour with its atoms mainly in one of their two hyperfine ground states. As a result of the coincidence of the lower hyperfine energy level for Rb-85 with the upper hyperfine energy level for Rb-87, the Rb-85 vapour effectively absorbs the light photons corresponding to the Rb-87 atoms dropping to their upper hyperfine energy level.

So the light emerging from the filter cell mainly consists of photons corresponding to the Rb-87 atoms dropping from their excited states to their lower hyperfine energy level. In other words, the filter cell removes most of the 795nm light photons and leaves mainly those with a wavelength of 780nm to pass into the resonance cell.

Now the resonance cell is filled with Rb-87 vapour, together with a 'buffer' gas. When the atoms of Rb-87 in the cell are in their ground state, there will be exactly the same number of valence electrons occupying each of the two hyperfine energy levels. However, when the 780nm light photons coming from the filter cell pass through the vapour, many of the photons interact with the Rb-87 atoms, which absorb their energy and shift their valence electrons up to an excited energy level.

These excited atoms quickly relax again, dropping down to one of the ground state hyperfine levels. The nett result is that a 'population imbalance' is created between the two hyperfine energy levels: more electrons will be in the upper hyperfine level than in the lower level. This interaction of the 780nm photons with the electrons in the Rb-87 vapour atoms is known as 'optical pumping'.

Metal cavity

As you can see, the resonance cell is housed inside a metal cavity and its dimensions are arranged to make it resonate electromagnetically at 6.834,682,612,8GHz. RF energy is fed into the cavity to excite it at this frequency, using the kind of system shown in Fig.2. A frequency synthesiser driven by the 10MHz crystal oscillator produces an RF output at close to 359.72MHz, and this RF is fed to a step recovery diode inside the resonance cell and cavity.

The diode effectively multiplies the 359.72MHz signal by 19 times. So it provides enough energy at the nineteenth harmonic of the 359.72MHz signal to excite the resonance cell at (19 x 359.72) = 6834.68MHz.

Two views of the Quartzlock E10-MRO Rb-vapour frequency standard. At top is the outside view showing the DB-9 connector (used for most external connections), plus the SMA connector for the 10MHz output at upper right. The lower view shows the inside, with the Rb 'physics package' at the rear.

The effect of this electromagnetic energy in the resonance cell is to cause many of the Rb-87 valence electrons to effectively transfer from the upper hyperfine energy level down to the lower level. This in turn makes it easier for the 780nm photons passing through the cell to re-excite the Rb-87 atoms once again, bumping their valence electrons up to an 'excited' level so that they can 'relax' again and fall back to one of the hyperfine levels.

The result of this fairly complex interaction is that when the RF energy fed into the resonance cell is at the exact frequency which corresponds for transfers between the two hyperfine levels of Rb-87, there are fewer of the 780nm photons emerging from the rear of the resonance cell and reaching the photodetector to its right. At frequencies that are either higher or lower than this, more of the photons pass straight through to reach the photodetector.

The overall effect of the rubidium physics package is therefore to provide a very accurate or high-Q filter, allowing the frequency of the 10MHz crystal oscillator to be 'disciplined' via a control voltage (applied to a varactor diode) to the exact frequency where the RF energy fed to the resonance cell results in maximum absorption of the 780nm photons.

Since the 6.834GHz energy is derived from the 10MHz oscillator and hence locked to it, this means that the frequency of the oscillator is held very accurately to 10.000MHz (±5 parts in 10^{-11}).

So that's the basic idea. However you might already be wondering how the frequency control feedback loop in Fig.2 can zero in to the correct frequency, if the RF energy fed into the resonance cell and cavity remains locked to a single frequency. How can it tell when everything is tuned for a dip or notch in the photodetector output?

That's done by introducing a small

Milestones in Atomic Clock Evolution

1944: The concept of atomic clocks developed by Isidor Rabi of Columbia University (USA). Rabi wins a Nobel Prize.

1948: Harold Lyons and his associates at the US National Bureau of Standards (NBS) achieve the first atomic frequency standard, using the resonance of ammonia at 23.870GHz.

1951: French physicist Alfred Kastler, working on a combination of optical resonance and magnetic resonance, develops the technique of 'optical pumping'. This played a key role in the development of masers, lasers and Rubidium frequency standards. Kastler was awarded a Nobel Prize for this work in 1966.

1954: J. R. Zacharias proposes the idea of an 'atomic fountain' clock, although this does not become feasible until 1989.

1955: Louis Essen and Jack Parry, working at the National Physical Laboratory (NPL) in Teddington (UK), achieve the first working cesium-beam atomic frequency standard.

1956: The first commercial cesium-beam frequency standard, the Atomichron, was developed by Zacharias, Richard Daly and Joseph Holloway at the National Company of Malden, Massachusetts (USA), working together with MIT. Between 1956 and 1960, about 50 Atomichrons were delivered, mainly to US Government agencies. They were very large and bulky devices.

1958: P. L. Bender, E. C. Beaty and A. R. Chi, working at the US Naval Research Laboratory, develop the concept of using optical detection of narrow Rb-87 hyperfine absorption lines, and also the idea of using Rb-85 vapour to filter out one of the hyperfine lines. Both concepts were the key to producing Rb-vapour frequency standards.

1960: R. J. Carpenter and his colleagues, and also M. Arditi, developed prototype rubidium-vapour oscillators.

1960-65: Now at Varian Associates in Beverly, Massachusetts, Joseph Holloway worked with Richard Lacey and Norman Ramsey to develop a cesium-beam tube only 16" (406mm) long. This was offered as a component to firms considering the manufacture of compact commercial Cs-beam frequency standards or 'clocks'. Then in 1964, a 12" (305mm) long Cs-beam tube was developed for Hewlett-Packard, to use in their first Cs-beam frequency standard (the HP5060A). This became famous as the 'flying clock'.

1964: The first operational Rubidium frequency standard was developed by P. Davidovits and R. Novick.

1967: HP acquires the manufacturing rights for Varian's cesium-beam tubes. Also in 1967, the 13th General Conference on Weights and Measures defined the second as "the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Cesium 133 atom".

1970: Matt Zepler, working for Plessey at Roke Manor in Hampshire (UK), develops an Rb-vapour oscillator that is small enough to fit as a component module in a 2U rack-mounting case. At about the same time, KVARZ, an institute in Gorky (Russia), developed a compact Rb-vapour frequency reference that was small enough to be fitted into mobile and airborne equipment.

1971: Hugo Fruhof and his team at Efratom Electronik GmbH in Munich (Germany) develop the FRK – a very small Rb-vapour oscillator. Fruhof and Efratom then moved to the USA, where they began manufacturing a series of compact Rb-vapour frequency standards – evolving into the 'FRS' units which became an industry standard. The FRS units measured only 4" x 3" x 2" (102 x 76 x 51mm). Efratom was acquired by Ball, then Datum and then Symmetricom.

1989: S. Chu, M. Kasevich and their colleagues at Stanford University in California demonstrate a Cs-fountain technique for measuring atomic resonance. Shortly afterwards, the first primary frequency standard based on this approach was developed by a group at the Laboratoire Primare du Temps et Frequences (LPTF) in France.

1992: Leon Cutler and Robin Giffard of HP Labs develop the much-improved HP 5071A Cs-beam clock, smaller and lighter than its predecessors but still measuring 524 x 425 x 133mm and weighing 30kg.

2000: Hewlett-Packard splits into two: HP (computers and printers) and Agilent Technologies (test and measuring instruments). The Precision Time and Frequency division becomes part of Agilent.

2005: Agilent sells its cesium frequency standard line to Symmetricom of San Jose, California.

2012: Dr Thomas Cao, Clive Green and Dr Cosmo Little, working at Quartzlock (UK) Ltd in Devon, England, develop an ultra-miniature Rb-vapour clock measuring only 51 x 51 x 25mm and weighing less than 150 grams – the E10-MRX.

2013: Symmetricom of San Jose sold to Microsemi Inc., a semiconductor firm in Aliso Viejo (Orange County, Southern California).

amount of FM (frequency modulation) into the output of the frequency synthesiser, so it swings cyclically above and below the correct frequency – usually at a low audio rate of about 70Hz. The amplifier following the photodetector is arranged to filter the detector's output and deliver an output voltage that's proportional to the second harmonic of the modulating frequency, at 140Hz.

It turns out that this second harmonic signal peaks at the exact frequency corresponding to the notch in the photodetector's DC output.

As you can see, most modern Rb-vapour standards use a microcontroller to ensure that the 10MHz oscillator remains locked. The microcontroller monitors the photodetector output via an ADC (analog-to-digital converter) and applies the phase error correction or 'disciplining' voltage to the oscillator's varactor via a DAC (digital-to-analog converter).

The micro is usually programmable in terms of the feedback gain and time constant, etc. In most cases, this can be done from a PC via an RS-232C serial cable.

Referring back to Fig.2, you may be wondering about that second DAC controlled by the micro and the magnetic coil it drives – wound around the resonance cell inside the physics package. What is that for?

While the energy difference between the two hyperfine ground state levels of the Rb-87 isotope is very stable at the value corresponding to 6.834,682,612,8GHz, it can vary slightly in response to changes in the ambient magnetic field.

As a result, the resonance cavity and the magnetic coil wound around it must be housed in a mu-metal shielding box to minimise external perturbations. The current through the magnetic coil is then adjusted by the micro to bring the apparent Rb-87 hyperfine transition frequency to the correct figure of 6.834GHz. The adjustment range is quite small – about $\pm 2 \times 10^{-9}$, which is why the function of the

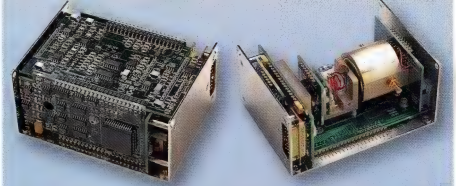
magnetic coil is usually described as for 'fine tuning'.

But wait – there's more!

Now while the accuracy and stability of these rubidium-vapour frequency standards is much better than that of a temperature-controlled crystal oscillator or 'TCXO', they're still not as good as a cesium-beam standard. That's why Cs-beam standards are regarded as the primary references for time and frequency, with Rb-vapour standards relegated to secondary status.

However, nowadays there is a fairly simple way to achieve greater accuracy from a Rb-vapour frequency standard. This is by using the 1pps pulses from a GPS receiver to 'discipline' the Rb-vapour standard. This allows an Rb-vapour frequency standard to achieve almost exactly the same accuracy and stability as a Cs-beam standard.

As you may be aware, the 1pps pulses from a GPS receiver have excellent long-term accuracy and stability, because they are locked to Cs-beam standards in the GPS satellites. However they vary significantly in the short term, due to both propagation changes and jitter in the GPS receiver circuitry.



Two views inside the SRS PRS10 Rb-vapour reference. On the left, only the outer mu-metal shield has been removed, showing two of the four PCBs. On the right, the three upper PCBs have been removed, to show the Rb discharge lamp and microwave absorption cell assembly.

On the other hand, Rb-vapour standards have excellent short and medium-term stability, with a low 'ageing' drift rate (approximately 5 parts in 10^{-10} per year). So disciplining an Rb-vapour standard with the 1pps pulses from a GPS receiver (over a significant period of time) provides the short and medium-term stability of an Rb-vapour standard with the long-term accuracy of a Cs-beam standard.

It also avoids needing to have the Rb-vapour standard recalibrated every couple of years, to compensate for its ageing drift rate. Many modern Rb-vapour frequency standards have the ability to lock to external GPS-derived 1pps pulses, while some have a GPS receiver built in. Either approach allows them to achieve this near Cs-beam performance.

For example, the Quartzlock E10-GPS unit, after being disciplined to GPS 1pps pulses for 24 hours, is specified to have a frequency accuracy of less than one part in 10^{-12}, with a short-term stability of less than three parts in 10^{-11} over a 1s period, less than one part in 10^{-11} over a 10s period, or less than three parts in 10^{-12} over a 100s period. That's very impressive! SC

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Build a state-of-the-art Mini Entertainment

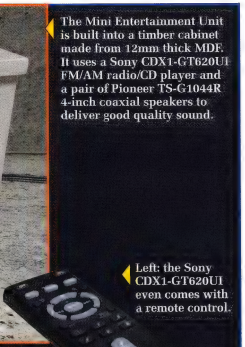
Have you wanted to build a really good quality stereo mantel radio with FM/AM reception and the capability for playing music from a flash drive, iPod, iPhone etc? Or perhaps you have lusted over a Bose Wave Music system but have been thwarted by the high price? Well, there is another, much cheaper way and it is based on a good-quality car FM/AM radio/CD player.

SILICON CHIP readers love building electronic projects and from time to time we get requests to design a project for a good quality mantel radio. However, over the years it has only taken us a few minutes' consideration to come to the conclusion that designing an FM/AM stereo radio of reasonable performance would simply not be a viable proposition when compared to the plethora of equipment available from retail stores.

The most recent request along these lines had us thinking differently though, especially when considering that most such consumer equipment has facilities for playing music from an iPod, iPhone, Android phone, flash drive or whatever. Presumably, any mantel radio project we designed would also need those facilities. Of course, that makes a SILICON CHIP design along these lines even more complicated and less viable.

But then we harked back to our first issue, in November 1987 when we used a AM/FM stereo radio-cassette player as the basis of a good quality mantel radio. Then, as now, people hankered after the good sound of an old valve radio instead of the restricted sound from tiny speakers in minuscule cabinets. And then as now, we concluded that using a car radio and car radio speakers was the way to go.

Now though, because of the way that consumer electronics has become so cheap, you get far more value; incredible value, in fact. Back in 1987 we could have purchased a no-name AM/FM stereo radio-cassette player for under $80. However, on that occasion we elected to use a top-of-the line Pioneer AM stereo/FM stereo radio cassette player we had on hand.



The Mini Entertainment Unit is built into a timber cabinet made from 12mm thick MDF. It uses a Sony CDX1-GT620UI FM/AM radio/CD player and a pair of Pioneer TS-G1044R 4-inch coaxial speakers to deliver good quality sound.

Left: the Sony CDX1-GT620UI even comes with a remote control.

By LEO SIMPSON

Centre

It would have cost many hundreds of dollars to buy new.

Sony radio

This time around we bought a Sony CDX1-GT620UI FM/AM radio/CD player for under $70. It can play discs in a number of formats and you can plug in a flash drive, MP3 player, iPod, iPhone or the auxiliary plug from an Android smart phone; no adaptor is required. It also comes with its own infrared remote control which seems a silly idea for a car radio but ideal for the application we wanted to use it for.

Furthermore, you can control it via your iPhone after downloading an app; something which wasn't even thought of in 1987.

As well, the Sony can drive front and rear speakers, incorporates an equaliser for a variety of sound quality settings and has outputs to drive an external 4-channel amplifier and powered subwoofer. In short, it has all the facilities you would expect in a premium car sound system.

Because the radio is designed for use in a car, it has far better RF performance than any domestic radio and has the advantage that you can store all your favourite stations, available at the push of a button. In fact, its overall performance ratings would probably be better than many typical domestic music systems costing many hundreds of dollars.

And while it might be controversial to compare its overall sound quality to that of a Bose Wave Music System, it is a great deal cheaper and does not require an external adaptor in order to hook up an iPhone or iPod. (The current model Bose Wave Music system with AM/FM radio/ CD player retails for $699. The top-of-the-line model with DAB+ reception has an RRP of $799).

In essence, all you need do to build a complete music system with the Sony car radio (or any other car radio) is provide loudspeakers and a suitable DC supply.

Buying the parts

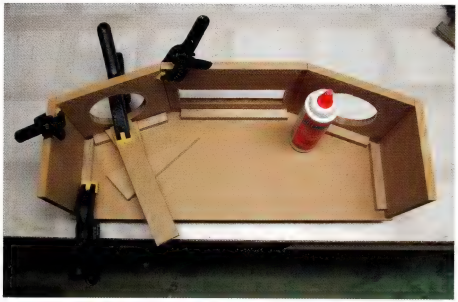
Before going further, we should discuss where to purchase the various components. While you will find that there are lots of on-line sellers of car radio equipment, virtually all of it sourced from Asia, we found it was quicker, more convenient and actually cheaper to buy from our local JB Hi-Fi store. At the store, you can physically examine and listen to what you are buying and there are often short-term in-store or website specials available. In the case of the Sony radio we purchased, it had been reduced twice and was way below its recommended retail price of $148.00.

The same comments apply to the loudspeakers we purchased. Initially, we purchased Pioneer 6-inch (150mm) 4-ohm coaxial speakers from JB Hi-Fi but when we began to draw up the cabinet plans, we realised that they would make the make the cabinet too bulky. It was a simple matter to go back to JB Hi-Fi and swap them for a pair of slightly more expensive Pioneer TS-G1044R 4-inch (100mm) 4-ohm coaxial speakers, at $49 for the pair. These come with separate 130mm decorative surrounds and mesh grilles which still makes them a little more bulky than we would have preferred.

Note that exchanging goods purchased on-line, particularly from overseas sellers, may be inconvenient, costly or simply not possible.

The mesh grille on the Pioneer speakers is desirable for most applications because there is a considerable risk that the coaxial tweeter or woofer

The Sony CDX1-GT620UI FM/AM radio/CD player (left) features a detachable control panel while the Pioneer TS-G1044R 4-inch speakers are supplied with decorative plastic surrounds and steel mesh grilles.



These two photos show the cabinet under construction. The holes in the front panels for the radio and the two speakers must be made before gluing and clamping the assembly together.

cone could easily be damaged in normal use.

If you want a more compact speaker, you could consider the Response 4-inch 4-ohm coax speakers from Jaycar (Cat. CS-2310). These are quite good performers but in their case, the detachable surround and grille does not fully protect the woofer cone.

Power supply

The power supply can be as simple as a DC plugpack rated to deliver between 13V and 14.4V at 1A or more. The upper limit of 14.4V is the maximum which is supplied to a car radio in normal use but they are probably designed for a maximum DC voltage of about 15V.

However, standard DC plugpacks may not be satisfactory as there might be too much hum and noise in the resulting sound. By all means try using a DC plugpack if you have one suitable but make sure that it delivers no more than 14.4V DC. Many DC plugpacks are quite poorly regulated, which means that their peak output voltage may be way above their nominal rating. For example, one unit I tried was rated at 12V DC but actually delivered around 19V with light loading.

The power supply we actually used was a switchmode unit rated for 12V DC at 2.8A. This proved to be noise-free as far as the radio's sound quality was concerned while delivering more than enough power (actually very loud

This view shows the general layout inside the cabinet. The radio is held in place using a curtain bracket and a machine screw, while the switchmode power supply is secured using double-sided foam adhesive. The antenna (brown wire) runs up one side of the cabinet and along the top and is held using gaffer tape.

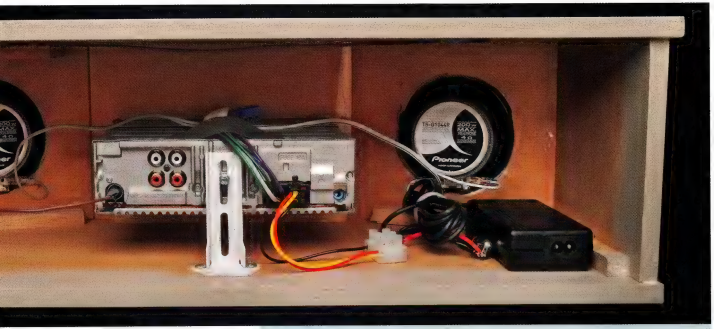
in a typical room) for normal listening.

This might be a little surprising, given that the Sony radio is specified to deliver up to 52 watts into four channels. Even if this is a music power rating, it would require far more than 2.8A for full power. We did not test its maximum power rating but we would assume that it would pull at least 10A when driven to full power. Fortunately, for normal listening a power supply capable of delivering between 1A and 2A will be more than adequate.

If there is too much hum or your plugpack's DC output is simply too high, you will need to feed it via a regulator module. The one we suggest is our MiniReg adjustable regulator from the December 2011 issue. This was based on an LM317T regulator delivering up to 1.5A but for this application, we suggest changing the LM317T to an LM338T which is rated to deliver up to 5A. The accompanying panel has all the details on the MiniReg.

Making the cabinet

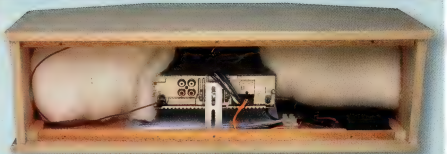
This is the hardest and most time-consuming part of this project. Rather than producing a straightforward rec-



tangular cabinet as we did originally, this time we wanted to produce a unit with more styling and possibly smaller. We had the Bose Wave Music system in mind as our inspiration. This unit comes in a surprisingly compact cabinet (371 x 106 x 218mm – W x H x D) and with a curved front. As already noted, the size of the speakers we selected, combined with the depth of the Sony radio's case meant that our cabinet would inevitably be considerably larger.

We also decided that making a cabinet with a curved front would be far too difficult for the majority of our readers and would add complications when mounting the radio and the speaker themselves. Therefore we decided on a cabinet which has the speakers angled back to make it more compact and also to improve the apparent stereo separation.

The resulting cabinet was made



Packing bonded acetate fibre in behind each speaker significantly improves the bass when combined with a close-fitting back panel (below).

The rear panel is made from 12mm-thick MDF and has a stiffener glued along the horizontal centre-line made from 12 x 12mm DAR pine timber.

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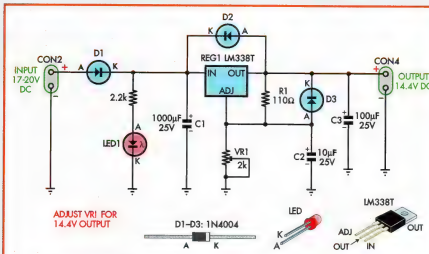
Fitting A Regulator To The Plugpack Supply



SC 2011 MINIREG ADJUSTABLE SUPPLY

Fig.1: the MiniReg circuit uses an LM338T adjustable regulator. D1 provides reverse polarity protection, while trimpot VR1 adjusts the output voltage.

IF THERE IS too much hum or your plugpack's DC output is simply too high, you will need to feed it to the radio via a regulator module.

The one we suggest is our MiniReg Adjustable Supply from the December 2011 issue. This was based on an LM317T regulator delivering up to 1.5A and is accommodated on a small PCB measuring only 35 x 38mm. For this application though, we suggest changing the LM317T to an LM338T which is rated to deliver up to 5A.

Circuit details

We are reproducing the main details of the regulator here – see Fig.1. The LM338T adjustable regulator provides a nominal 1.25V between its OUT and ADJ (adjust) terminals. We say it is a "nominal 1.25V" because, depending on the device, it can be anywhere between 1.2V and 1.3V. This doesn't really matter though, because we can adjust the output voltage to the required level using trimpot VR1.

The output voltage from REG1 is set by the 110Ω resistor (R1) between its OUT and ADJ terminals and by the resistance between the ADJ terminal and ground. This works as follows: by using a 110Ω resistor and assuming an exact 1.25V reference, the current flow through the resistor is set at 11.36mA. This current also flows through trimpot VR1.

This means that if VR1 is set to a value of 1.15kΩ, then the voltage across this trimpot will be 1.15kΩ x 11.36mA = 13.06V. This voltage is then added to the regulator's 1.25V reference to derive the output voltage – in this case 14.31V.

In practice, the current flow out of the ADJ terminal also contributes slightly to the final output voltage. This current is of the order of 100µA, so if VR1 is set to 1.16kΩ, this can add 0.12V to the output, ie, we get 14.43V. In practice, its just a matter of adjusting VR1 to set the output to exactly 14.4V.

Diode D1 provides reverse polarity protection. This means that if you connect the supply voltage around the wrong way, you cannot do any damage.

Diode D2 protects the regulator if the input becomes shorted to ground while it is powered up. Without D2, current would attempt to flow back from the output capacitor through the regulator to the shorted input and that could kill it. But D2 becomes forward biased and conducts, effectively preventing any reverse current flow through REG1.

Diode D3 is also included to protect REG1. It does this by clamping the voltage between the ADJ terminal and the OUT & IN terminals in the event that one of the latter is shorted to ground.

Finally, capacitors C1 & C2 reduce ripple and noise by bypassing the IN (input) and ADJ terminals respectively. C3 prevents regulator oscillation by swamping any low-value capacitance that may be connected to this output.

Construction

All the parts for the MiniReg are mounted on a PCB coded 18112111. Fig.2 shows the parts layout.

Begin the assembly by installing the 110Ω resistor (R1) and the three diodes, making sure the latter are all orientated correctly (the banded ends are the cathodes). That done, install the wire link. This link takes the place of CON3 as fitted to the original MiniReg and is installed because an on/off switch is not required in this application.

The three capacitors can go in next, again taking care with their

from a sheet of 12mm-thick medium density fibreboard (MDF) measuring 600 x 900mm. The two panels for the speakers are angled back by 20°.

While this might seem like a fairly simple design, it proved to be quite a challenge to get all the angled cuts correct. Ultimately, a certain amount of planing was required to make sure that all panels fitted together reasonably closely. Even then, some wood filler was required to cover minor blemishes before the cabinet was sanded and finished. The finished cabinet dimensions are 565 x 177 x 218mm deep (W x H x D). These dimensions do not include the speaker escutcheons and grilles and the radio itself.

Ideally, anyone attempting to produce a cabinet along these lines needs access to a drop saw or bench saw

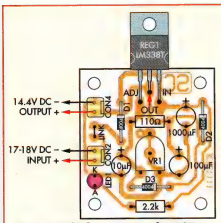
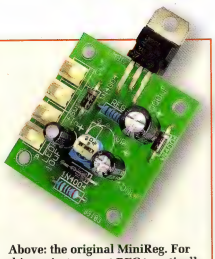


Fig.2: install the parts on the PCB as shown here. LED1 and its associated 2.2kΩ resistor are optional.



Above: the original MiniReg. For this project, mount REG1 vertically and install LED1 and a link in place on CON1 & CON3.

MiniReg Parts List

1 PCB, code 18112111, 35 x 38mm
2 2-way polarised pin headers, 0.1in spacing
1 120 x 140mm aluminium sheet for heatsink
1 TO-220 insulating washer
1 insulating bush
1 M3 x 100mm machine screw & nut
1 2kΩ horizontal trimpot

Semiconductors

1 LM338T voltage regulator (REG1)
3 1N4004 power diodes (D1-D3)
1 3mm red LED (LED1, optional)

Capacitors

1 1000µF 25V electrolytic
1 100µF 25V electrolytic
1 10µF 25V electrolytic

Resistors (0.25W, 1%)

1 110Ω 1 2.2kΩ

orientation since they are all electrolytics. Follow with the three 2-pin headers (CON1, CON2 & CON4), then install the 3-terminal regulator. The latter should be mounted vertically at full lead length (not horizontally as shown in the photo), so that it can later be fastened to a heatsink.

The PCB assembly can now be completed by installing LED1 (it takes the place of CON1 in the December 2011 circuit). This LED is optional; simply leave it out if you don't need it (you can also omit its series 2.2kΩ resistor).

You must fit a heatsink?

The LM338T must be mounted on a heatsink which can be just a sheet of 1mm thick aluminium measuring around 120 x 140mm and mounted vertically in the rear of the cabinet.

Note that it will be necessary to electrically isolate the regulator's tab from the heatsink. The reason for this is that the regulator's tab sits at the output voltage (ie, 14.4V)

To isolate the tab, use a TO-220 insulating washer and bush and secure the assembly to the heatsink using an M3 x 10mm screw and nut. Fig.3 shows the details.

Adjusting the output

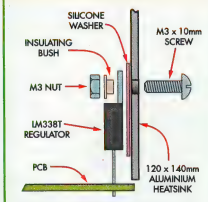


Fig.3: the LM338T regulator must be isolated from the aluminium heatsink using a silicone insulating washer and bush.

The input voltage applied to CON2 must be several volts higher than the required output voltage. This is necessary in order to provide regulation.

The minimum voltage across REG1 required for regulation is called the "dropout voltage". For the LM338T, this voltage varies with the current and is typically 1.5V for currents below 200mA, rising to 1.7V at 500mA and 2V at 1A.

Note that the voltage drop across diode D1 must be added to the dropout voltage in order to calculate the required input voltage.

For example, if the load draws 2A or more and the required output voltage is 14.4V, then the input voltage must be 14.4V plus 0.7V (to compensate for voltage across D1) plus 1.5V (for the dropout voltage), ie, the input voltage must be at least 2.2V higher than the output voltage.

Therefore, we need to apply at least 16.6V minimum to the input for regulation. This is the absolute minimum to ensure correct regulation. Note also that any ripple on the input supply that drops below the required voltage will cause problems, since the supply will not be regulated during these low-going excursions.

Once you've connected the supply, it's just a matter of adjusting trimpot VR1 to set the required output voltage to 14.4V. You will need to make up two matching cables with 2-way polarised header connectors for the input and output connections.

If ripple is still present on the output of the regulator, reduce the output – down to as low as 12V if necessary.

which can do precision angled cuts. I used a standard circular saw with a facility to angle the blade but making the required precision cuts needs a very steady hand. The photos show how the cabinet was assembled, with cleats, PVA glue and plenty of clamps.

By the way, before the cabinet is assembled, you need to make cut-outs in the three MDF front-panel sections, to suit the radio and the two speakers. The Sony radio we used has a control panel which is detachable and it is good idea to have this removed while you do any measurements and installation work. The cut-out for the radio must be very tight; no more than 1mm clearance for the height and width of the case, because the front panel trim will not cover any gaps.

It is also most important to have the

Our First Car Radio-Based Project

These photos show the construction of our first car radio-based project from the November 1987 issue. The Pioneer KE-A433AM car radio in question was quite a good unit, with PLL synthesiser tuning of the AM & FM bands and wide and narrow-band reception on AM. It also featured stereo reception from CQUAM transmissions, 70μs equalisation for metal tape cassettes and 18 presets for the AM & FM bands.

We teamed it with a pair of small oval 8-ohm car speakers and housed it in a cabinet made from dressed Radiata pine timber, tinted and finished with matte Estapol. The front panel was covered with beige grille cloth.

The cabinet was relatively large but simple to make, with the panels screwed and glued to internal cleats (the rear panel has been removed for these photos).

This was before the days of regulated DC plugpacks so we used a conventional power supply employing a 15V 1A transformer feeding a bridge rectifier, a 4700μF 25V capacitor and a regulator circuit based on a 7812 3-pin regulator "jacked up" with two diodes in series with its GND terminal to set the output to 13.4V DC.

radio cut-out exactly centred (horizontally) in its MDF panel. Similarly, the circular cut-outs for the two speakers must be made so that they are equidistant from the top and bottom edges of the MDF panels and also equidistant horizontally from the corners of the finished cabinet (the accompanying photos tell the story).

We painted the cabinet in a light-grey semi-gloss oil-based enamel. This was probably a mistake because it is more difficult to apply (and clean up afterwards) than an equivalent water-based acrylic paint. Either way, the cabinet needs to be carefully sanded and filled where necessary with wood filler, painted with a water-based acrylic undercoat and then sanded again.

Take our word for it and don't attempt to do the top coats with a brush because you will find it almost impossible to avoid brush marks. Instead, use a small short nap roller intended for matt and semi-gloss acrylic paint – you will get a much better finish.

Instead of fitting rubber feet to the base of the cabinet, we used stick-on felt pads which can be purchased cheaply from hardware stores.

Installing the components

As can be seen from the photo of the rear of the unit, the radio is anchored by a single screw and a curtain bracket at the rear. The various connections for the speakers were brought out to a multi-way terminal block and the speaker connections hooked up. We then simply taped all those connections and the unused wires for the rear speakers to the top of the radio case using gaffer tape (crude but effective).

Similarly, we brought the three supply connections (+12V, memory supply and GND) to another terminal block and made connections to the compact switchmode power supply via a jack connection and then again, taped it all to anchor it. The switchmode supply itself was anchored using double-sided adhesive tape.

You also need an aerial connection and to do this we used a 60cm length of wire soldered to the tip connection of a 3.5mm jack plug which was then pushed into the aerial socket. We then taped the wire inside the cabinet. In most urban areas this will give good radio reception.

Losing memory

Now one the drawbacks of the simple supply connection we used is that if you turn off the power at the wall socket, you will lose all the user settings such as the clock, favourite stations, sound set-up and so on. To keep these settings, you need to have a +12V supply permanently connected to the memory supply terminal (as it is in a normal car set-up).

The best way to provide a standby 12V supply is to install a small 12V SLA battery and then trickle-charge it from the main supply via a 1N4004 power diode and a resistor, say 2.2kΩ 0.25W, to give it a permanent float charge of just over 5mA. Again, the battery could be simply secured inside the cabinet with double-sided adhesive tape.

Improving the bass

As a final finishing touch to the cabinet, we fitted an MDF back panel. As shown in one of the photos, this has an access hole for the 2-pin mains plug for the power supply. The rear panel does improve the bass somewhat but it still won't be as good as it would be if the cabinet (s) were specifically designed to suit the speakers.

Incidentally, as a further refinement, you could add extra terminals to the rear of the cabinet to allow rear speakers to be connected. SC

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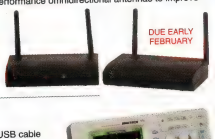

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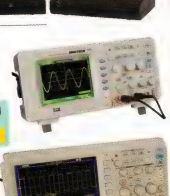

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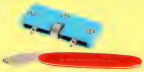

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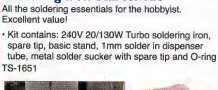

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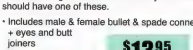

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Soldering Stations

60W Lead-Free with LCD Panel

Suited to lead-free soldering and is just as capable with ordinary leaded solder.

- Soft insulated rubber grip
- Silicon rubber sheathed power cable
- Mains powered
- Digital LCD display
- Temperature range 160˚C to 480˚C

TS-1390

$149.00

60W ESD Safe Rework Station

Complete solder/desolder station for production and service use.

- Microprocessor controlled
- Dual LCD displays
- Temperature range 160˚C to 480˚C
- Celsius and Fahrenheit display

TS-1574

$299.00

DIY Packages

Make Your Home Look Alarmed

No one will know that you don't have the full system. Looks like the real thing.

Includes:
- Siren cover
- Strobe
- 3 alarm stickers

LA-5130 **WAS $49.95**

$39.95

SAVE $10

2-Zone Alarm Kit

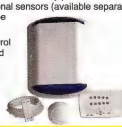
Simple two zone, two wire alarm for small to medium size premises. Includes one passive infrared sensor for large areas and a reed switch for one entry point such as a door or window. Additional sensors (available separately **LA-5481 $24.95**) can be added if required.

- Includes: 2-Zone control unit, PIR sensor, Reed switch & 25m cable

LA-5480 **WAS $69.95**

$59.95

SAVE $10



8 Zone Wireless Alarm Kit

The system "learns" what sensors are connected and the part arm function allows you to protect certain zones while others are disarmed. Easy to install, ideal for rented or temporary premises.

- Kit includes siren, keypad, PIR sensor, reed switch and power supply

LA-5150 **WAS $169.00**

$149.00

SAVE $20

Jaycar Electronics
Better, More Technical

SIGHT & SOUND

HDMI Repeater with Infrared Extender

A clever device that allows you to hide your HDMI audio/video sources in cabinets or behind walls but still be able to control them. Supporting up to 1080p and HDCP, the IR and AV signal transmits through a single length of HDMI cable up to 45m.

- Gold plated input/output connections

AC-1641

NEW

$99.00

HDMI Over Cat 5/6 Extender

Extend your HDMI signal up to 60m* using a single CAT 5/6 cable. Both unshielded twisted pair (UTP) and shielded twisted pair (STP) cables may be used, however shielded is recommended.

- Supported resolution: 480p, 720p, 1080i, 1080p
- Mains adaptor included

AC-1681

NOTE: *Distance will vary depending on the resolution and cable specifications used. See website for full specifications.

$149.00

IR Remote Control Extender

Extend the range of your IR remote control up to 100m. IR commands are sent by the transmitter via 433MHz signal to the receiver in another room. Mains plugpacks for transmitter and receiver included.

- Transmission range: up to 100m
- Size: 100(Dia.) x 120(H)mm

AR-1817 **WAS $49.95**

$29.95

SAVE $20

2.4GHz DIGITAL Wireless HDMI AV Sender/Receiver

Transmit high definition audio and video signals from your HD equipment to your HDTV or HD monitor up to 50m away.

- 2 x 1m HDMI leads included
- Up to 1080p output resolution
- Size: 151(L) x 116(W) x 26(H)mm

AR-1871

NEW

$149.00

HDMI Display Receiver

Allows you to stream videos, music and photos wirelessly from your computer or DLNA enabled Android Smartphone or Tablet.

- Doubles as a Wi-Fi router
- Supplied with software and power adaptor (HDMI cable available separately)

AR-1914

NEW

$169.00

Audio Leveller & Converter

HDMI Audio Signal Volume Leveller

Sorts out those annoying fluctuations in volume while channel surfing or between the TV shows themselves and the advertisements.

- Mains power supply included
- HDMI in/out ports

AC-1615 **WAS $99.00**

$89.00

SAVE $10

USB 2.0 Audio Converter

Allows you to output audio from your PC or Apple® computer in high fidelity 24-bit 192kHz audio via USB.

- Input: USB 2.0
- Output: 6.35mm headphone, 2 x RCA and TOSLINK

AC-1616

WAS $99.00

$89.00

SAVE $10

Foxtel® Approved Socket Wall Plates

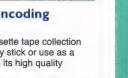
For splitting your FOXTEL® signal to two outlets.

- FOXTEL® approved

2 x F61 Socket Wall Plate
LT-3041 $6.95 (shown)

2 x F61 and RJ12 Socket Wall Plate
LT-3058 $7.95

NEW FROM $6.95



Remote Control AV Selector

Eliminates cable hassles, add up to 3 AV sources to your home theatre's AV inputs. See website for full specifications.

- DC power supply
- 9VDC / 500mA power

AC-1674 **WAS $59.00**

$49.00

SAVE $10

Stereo Amplifier with Remote Control

Rated at a generous 100 watts RMS per channel and has a flat frequency response from 20Hz to 20kHz. Includes remote control to adjust input source, volume etc.

- 2 x 100WRMS
- Inputs for Tape, Tuner, AV1, AV2, CD, Phono

AA-0470

Also available: **200WRMS Per Channel Stereo Amplifier** AA-0484 $329.00

$169.00

Cassette USB/SD Encoding Music Box

Digitally encode your old cassette tape collection straight to SD card or memory stick or use as a standard cassette player with its high quality amplified internal speakers.

- Built-in amplifier and stereo speakers

GE-4139

$99.00

USB Converters

USB to 1080p HDMI

Add HDMI port to your computer with this convenient adaptor. Simply install the driver, connect the device to your USB 2.0 port then connect to your extra display and away you go.

- Add up to 6 extra displays to a PC (requires 6 adaptors)

XC-4972 **WAS $79.95**

$69.95

SAVE $10

USB to DVI Adaptor

Connect your monitor to the computer via the USB 2.0 port without buying additional graphics cards. Use up to 6 simultaneously to run screen arrays.

- Powered via USB

XC-4879

WAS $69.95

$59.95

SAVE $10

2.4GHz Digital Wireless Speakers

Pop this pair of speakers in the backyard and the 2.4GHz DIGITAL audio transmitter will pipe crystal clear audio to the units up to 30m away.

- Powered by included mains adaptor or 6 x AA batteries (not included)

AR-1891

$119.00

In-store only. Limited stock.

To order call 1800 022 888

www.jaycar.com.au

Savings off original RRP. Limited stock on sale items

AUTO & OUTDOORS

Jaycar Electronics
Better, More Technical

In-Car Communication

FM Transmitter Kit with In-line Antenna

Play MP3 music over your car stereo. Simply plugs into a cigarette lighter socket and will play audio tracks from a SD/MMC card, USB flash drive, iPod®, or MP3 player directly through the FM band on the car stereo.

- Includes a remote control

AR-3104

$39.95

Don't Get FINED!

Avoid the risk involved with using your mobile handset whilst driving by using these simple Bluetooth® hands free car kit. Up to 10m Bluetooth® range.

Bluetooth® Hands Free Car Kit

Accept and reject calls with the push of a button.

- Built-in speaker and microphone
- Adjustable volume and echo cancellation

AR-3121 **WAS $29.95**

$19.95
SAVE $10

Bluetooth® Hands Free Car Kit with LCD

Safely dial or answer phone calls hands-free whilst driving with this user friendly visor mounted Bluetooth® car kit.

- Large LCD display
- Voice operated dialing
- Allows 2 phones to connect simultaneously

AR-3122 **WAS $59.95**

$49.95
SAVE $10

Car Charger/Audio Kit for iPhone®/iPod®

Ideal for charging your iPhone®/iPod® while connected to the audio input in your car stereo. Includes a USB cigarette lighter charger.

- Lead length: 1.2m

MB-3653 **WAS $24.95**

$19.95
SAVE $5

Universal USB Mobile Phone Car Charger

Delivers 5VDC up to 1A via the USB output, and includes a universal USB charging lead with 9 interchangeable tips to match all the most common mobile phones.

- Input: 12 - 24VDC
- iPhone®/iPod® plugs included

MP-3578

$19.95

UHF Car Antennas

Robust and durable antennas to suit cars, RVs and trucks. Two models to choose from. Each features a 5m pre-terminated cable with FME socket and PL259 adaptor so no tools are required.

4dBi Flexible UHF Antenna

- 407mm long
- Includes 'L' guard mount bracket

DC-3073 $59.95

NEW FROM $59.95

3 & 6dBi UHF Premium Antenna Kit (shown)

- Stainless spring & elevated feed base
- 450mm (3dBi) and 900mm (6.5dBi) long
- Includes 'L' guard mount bracket and bull bar bracket

DC-3071 $119.00

Pure Sine Wave Inverters

Range in power from 180 to 2000 watts and provide stable and reliable power in mobile and permanent installations. All models have a USB port for powering USB gadgets. See website for full specifications.

- 12VDC

FROM $125.00

In-store only. Limited stock. Not available online.

180W	MI-5160	WAS $139.00 **NOW $125.00**	SAVE $14.00
380W	MI-5162	WAS $179.00 **NOW $159.00**	SAVE $20.00
600W	MI-5164	WAS $259.00 **NOW $229.00**	SAVE $30.00
1000W	MI-5170	WAS $449.00 **NOW $399.00**	SAVE $50.00
1500W	MI-5172	WAS $674.00 **NOW $599.00**	SAVE $75.00
2000W	MI-5176	WAS $899.00 **NOW $799.00**	SAVE $100.00

10% OFF

2.4GHz Rear View Mirror Reversing Camera - Wireless

Transmits video signals via the 2.4GHz band to the monitor which can be mounted internally or externally. The monitor fits securely over your existing rear view mirror and can be quickly removed when needed.

- 3.5" LCD colour screen
- Range: up to 80m
- Size: 280(L) x 95(H) x 26(D)mm

QM-3795 **WAS $169.00**

$149.00
SAVE $20

In-store only. Limited stock.

Battery Monitor

Simply plugs into your car's cigarette lighter socket to indicate alternator and battery status. Compatible with 12VDC systems.

- Size: 85(L) x 75(W) x 15(D)mm

PP-2142

$9.95

OBD2 Plug / Memory Saver

Use this memory saver lead to store, and restore all of your vehicles fault codes, radio settings, alarm settings, keyless entry codes, and more.

- 1m length

PP-2140

$12.95

Back-up Battery Case to suit iPhone 5®

Eliminate the short battery life of the iPhone 5® with this battery extender. Provide an extra 300 hours of standby time.

- Acts as a protective case
- Battery capacity 2000mAh

MB-3695

iPhone® not included

$39.95

Power Banks

E-Charger Power Bank 12V/USB Charger

Designed for use on 12V vehicles and can assist if the starter battery is a bit low. See our website for full specifications.

- 240VAC mains charger supplied
- Size: 250(W) x 110(L) x 80(H)mm

MB-3597 **WAS $29.95**

In-store only. Limited stock.

$24.95
SAVE $5

Never be caught out with a flat phone battery. Simply connect your phone or other mobile device for a quick charge.

USB Power Bank with 5000mAh Battery

- 2A and 500mA USB port
- Charges 2 devices at once

MB-3644 **WAS $59.95**

$39.95
SAVE $20

Solar Mobile Charger

A pocket sized solar panel with a built-in lithium battery so you can charge your gadgets anytime, anywhere.

- Compact & lightweight
- 2 x USB sockets

MB-3598

$49.95

Jaycar Electronics
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ARDUINO PROJECTS

USB Lipo Charger for Arduino

Charge Li-Po cells from any USB source, USB plugpack, laptop or PC.

$12.95

- 3.7V output for a single Li-Po cell
- Micro-USB jack
- Size: 27(W) x 16(H) x 10(D)mm

XC-4243

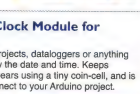
USB-Boost Module - Arduino Compatible

Takes a power input of 1.2 to 4.5V, and boosts it to a regulated 5V output up to 500mA. Perfect for powering Arduino projects from batteries, such as a single 3.7V Li-Po cell.

$12.95

- USB output jack
- Low-battery warning LED

XC-4239



USB-Serial Adaptor Module - Arduino Compatible

Connects to the USB port on your computer and acts as a virtual serial port, converting the USB signals to either 5V or 3.3V logic level serial data.

- Size: 46(W) x 26(D) x 10(H)mm

XC-4241

$22.95

Arduino Modules

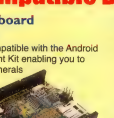
Humidity & Temperature Sensor Module for Arduino

Measure temperature and relative humidity using a simple interface that requires just three wires to the sensor: GND, power, and data.

- -4°C to +125°C temperature range with +/-0.5°C accuracy
- 0-100% relative humidity with 2-5% accuracy
- 3 to 5V operation

XC-4246

$19.95



Real-Time Clock Module for Arduino

Perfect for clock projects, dataloggers or anything that needs to know the date and time. Keeps accurate time for years using a tiny coin-cell, and is very simple to connect to your Arduino project.

- Battery included

XC-4272

$29.95

IR Temperature Sensor Module for Arduino

Connect this to your board and point it at a surface or heat source to remotely measure its temperature. This is our special version of the industrial infrared remote thermometer units with an onboard power supply, communication support and a software library and examples supplied.

- 3.3 to 5V operation
- -33 to +220°C measurement range, 1 second response time

XC-4260

$34.95

Arduino Compatible Boards

USBDroid with Onboard Android/USB Host

Specially designed to be compatible with the Android Open Accessory Development Kit enabling you to build your own Android peripherals to connect your phone to whatever you like.

- Built-in charger

XC-4222

$69.95

EtherTen

Includes onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.

- ATmega328P MCU running at 16MHz
- 10/100base-T Ethernet built-in

XC-4216

$69.95

EtherMega

The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, Power-over-Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.

- 10/100base-T Ethernet built-in
- 54 digital I/O lines
- 16 analogue inputs

XC-4256

$119.00

Arduino Shields

RFID Lock Shield Kit

This shield enables your Arduino to control a door lock using an electric strike plate and one of a number of commonly available RFID modules.

- Supported readers include ID12, ID20, RDM630, RDM880, and HF MultiTag

XC-4215

$29.95

Security Sensor Shield Kit

Allows up to 4 security sensors to be connected to an Arduino with full End-Of-Line (EOL) support to detect tampering with the sensors or cable. EOL technology allows the system to detect a variety of events using a single cable pair to the sensor.

- Status LEDs on each channel

XC-4217

$27.95

8 Channel Relay Driver Shield

Drive up to 8 relays from an Arduino using just 2 I/O pins. Perfect for home automation projects when combined with relay **SY-4052** (available separately **$8.95**) and DIN-rail relay mounting base **SY-4063** (available separately **$4.95**).

- LED status displays

XC-4276

$34.95

Also available
4 Channel Relay Driver Module for Arduino XC-4278 $13.95

Stackable Header Set for Arduino

The perfect accessory to the ProtoShield Basic, Pro, and vero type boards when connecting to your Arduino compatible project.

- 2 x 8 pin and 2 x 6 pin included to suit the Eleven (XC-4210), EtherTen (XC-4216), USBDroid(XC-4222) and ProtoShields

HM-3207

$2.95

ATmega328P MCU with Arduino Uno Bootloader

An Atmel AVR ATmega328P microcontroller to build customised Arduino compatible projects. Includes 16Mhz Crystal Oscillator.

- Pre-installed Arduino Uno bootloader

ZZ-8726

$9.95

4 Channel PoE Midspan Injector for Arduino

Power up to 4 EtherTen's (XC-4216) or EtherMega's (XC-4256) with DC from a low cost plugpack across your home or office network cables. It isolates and powers the correct wires automatically.

- 4 channels of input/output jacks

XC-4254

$26.95

To order call 1800 022 888

www.jaycar.com.au

Savings off original RRP. Limited stock on sale items

KIT PROJECTS

Jaycar Electronics
Better. More Technical.

Voltage Regulators

Regulated Voltage Adaptor Kit

Ref: Electronics Australia August 1997

A low-powered DC converter suited for many applications such as a peripheral computer power supply, powered speakers, modems, music/MIDI keyboards, etc. PCB and electronic components included.

- PCB: 52 x 19mm

KA-1797

$7.95

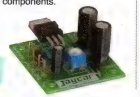
Voltage Regulator Kit

Ref: Silicon Chip Magazine May 2007

Provides up to 1,000mA at any voltage from 1.3 to 22VDC. Ideal for experimental projects or as a mini bench power supply etc. Kit supplied with PCB and electronic components.

- PCB: 38 x 35mm

KC-5446



$16.95

Improved Low Voltage Adaptor Kit

Ref: Silicon Chip Magazine May 2008

Runs a variety of devices such as CD or MP3 players from your car cigarette lighter sockets or even powered speakers from the power supply inside your PC. It will supply either 3V, 5V, 6V, 9V, 12V or 15V and (when used with an appropriate input voltage and heat sink) deliver up to 4A at the selected output voltage.

- Kit includes screen printed PCB and all specified components (heatsink not included)
- PCB: 108 x 37mm

KC-5463

$17.95

Speed Control Kit for Induction Motors

Ref: Silicon Chip Magazine April/May 2012 + Aug 2013

Control induction motors* up to 1.5kW (2HP) to run machinery at different speeds or controlling a pool pump to save money. Also works with 3-phase motors. Full form kit includes case, PCB, heatsink, cooling fan, hardware and electronics (including revisions from the August Silicon Chip article). An advanced project for an experienced constructor.

KC-5509

NOTE: *Does not work for motors with centrifugal switch

$249.00

12V 120W 3-Step MPPT Solar Charger Kit

Ref: Silicon Chip Magazine February 2011

Designed for use with 40W to 120W 12V solar panels and lead acid batteries and provides 3-stage charging with the option of equalisation and with MPPT (Maximum Power Point Tracking). Operation is for 12V panels and batteries. Kit includes PCB, all components and case.

- Charge indicator LEDs
- Temperature compensation for charge voltage
- 3-step charging
- PCB: 111 x 85mm

KC-5500

$129.00

12/24VDC 20A Motor Speed Controller Kit

Ref: Silicon Chip Magazine June 2011

Control the speed of 12 or 24VDC motors from zero to full power, up to 20A. Features optional soft start, adjustable pulse frequency to reduce motor noise, and low battery protection. The speed is set using the onboard trimpot, or by using an external potentiometer (available separately, use **RP-3510 $2.25**).

- Kit supplied with PCB and all onboard electronic components
- Suitable enclosure: UB3 **(HB-6013 $3.95)** sold separately
- PCB: 106 x 60mm

KC-5502

$39.95

Soft Start Kit for Power Tools

Ref: Silicon Chip Magazine July 2012

Stops that dangerous kick-back when you first power up an electric saw, router or other mains-powered hand tool. This helps prevent damage to the job or yourself when kick-back torque jerks the power tool out of your hand. Kit supplied with PCB, silk screened case, 2m power cord and specified electronic components.

- 240VAC 10A
- PCB: 81 x 59mm

KC-5511

$49.95

Universal Power Supply Regulator Kit

Ref: Silicon Chip March 2011

One small board and a handful of parts will allow you to create either a regulated 15V rail or +15VDC single voltage from a single winding or centre tap transformer (not included).

- Includes all PCB and components for board, transformer not included
- PCB: 72 x 30mm

KC-5501

$14.95

240V 10A Motor Speed Controller Kit

Ref: SC Feb/Mar 2014

An improvement on our successful KC-5478 Motor Controller Kit. Designed for controlling typical brush motor tools such as electric drills, saws and routers. The new design is easier to build and features soft start and improved overload protection. The case has the tricky cut-outs pre-machined, but a little bit of extra drilling is required to complete the project. Kit includes machined case, overlay PCB and electronic components.

KC-5526

KIT DUE LATE MARCH

NEW

$149.00

3V - 9V DC to DC Converter Kit

Ref: Silicon Chip March 2004

Allows you to use regular Ni-CD or Ni-MH 1.2V cells, or alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no time! Kit supplied with PCB, and all electronic components.

- PCB: 59 x 29mm

KC-5391

$15.95

DC Relay Switch

Ref: Silicon Chip November 2006

An extremely useful and versatile kit that enables you to use a tiny trigger current - as low as 400mA at 12V to switch up to 30A at 50VDC. It has an isolated input, and is suitable for a variety of triggering options.

- Kit includes PCB with overlay and all electronic components with clear instructions.

KC-5434

$16.95

12VDC Relay Card

This kit will close a relay's contacts with as little as 5mA to trigger the circuit. Use the relay to sound buzzers, switch on lights, operate solenoids, trigger alarms, etc.

- Kit includes PCB, relay and electronic components

KG-9142

$9.95

Jaycar Electronics — Better. More Technical

POWER PROJECTS

Power Monitors

Digital Mains Timer

Control lighting or powered appliances with this programmable timer.

- 8 on/off programmes across 16 combinations of days or blocks of days
- Internal battery backup
- Rated up to 10A

MS-6110

$24.95

Grid-Connect Solar Power Monitor with USB Interface

Measures the power consumption of your home, the power being produced by your solar array, and also gives you a "balance" of the power you are consuming versus what your solar array is producing.

- Uses 433MHz to wirelessly transmit data
- Stores up to 2 years of data

MS-6167 **WAS $149.00**

NOTE: Only works with NET-METER grid-connect solar systems.

$129.00

SAVE $20

"Gas Mantle Look" Lamp

This compact lamp opens to reveal a lampshade-like diffuser equipped with a powerful 1W LED. Collapses flat and can be used as a flashlight.

- Requires 3 x AA batteries

SL-2717 **WAS $14.95**

$12.95

SAVE $2

10" Solid LED Light Bar for 4WD/Marine

Waterproof and shock proof LED light bar for 4WD or marine use. Extremely high light output and features a near unbreakable 100% polycarbonate front lens cover. Supplied with alloy mounting feet, stainless steel hardware, and a wiring harness with remote rocker switch and relay.

- 50,000+ hour life span
- 4340 Lumens

SL-3914 **WAS $349.00**

$329.00

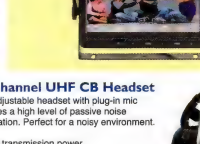
SAVE $20

Ultimate Rear-View System

Enables you to monitor the area to the rear of a large vehicle with a wider field-of-view. Fitted with a SHARP® CCD device with 18 x IR LED's for night vision illumintation. Supplied with 5m of pre-terminated connecting cable and a remote control.

- 7" LED display with two video inputs
- 12 or 24VDC
- IP65 rated

QM-3742



NEW

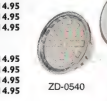
$199.00

LED Downlights

Ideal for caravans, mobile homes, household lighting, shop fittings, or anywhere a bright downlight is required.

- 24 high output 2835-type SMD LEDs
- 450 lumens

BUY ANY 2 FOR $25 SAVE $4.90



ZD-0544

12VAC/DC MR16

120°	Cool White	ZD-0540	$14.95
120°	Warm White	ZD-0541	$14.95
60°	Cool White	ZD-0542	$14.95
60°	Warm White	ZD-0543	$14.95

240VAC GU10

120°	Cool White	ZD-0544	$14.95
120°	Warm White	ZD-0545	$14.95
60°	Cool White	ZD-0546	$14.95
60°	Warm White	ZD-0547	$14.95

ZD-0542

ZD-0540

$14.95 ea

75 Channel UHF CB Headset

This adjustable headset with plug-in mic provides a high level of passive noise attenuation. Perfect for a noisy environment.

- 0.5W transmission power
- Up to 3km range
- Push to Talk (PTT) function
- Scan channel, call tone and monitor functions
- Mains charger included

DC-1052 **WAS $119.00**

$99.00

SAVE $20

YOUR LOCAL JAYCAR STORE - Free Call Orders: 1800 022 888

• AUSTRALIAN CAPITAL TERRITORY

Belconnen	Ph (02) 6253 5700
Fyshwick	Ph (02) 6239 1801

• NEW SOUTH WALES

Albury	Ph (02) 6021 6788
Alexandria	Ph (02) 9699 4699
Bankstown	Ph (02) 9709 2822
Blacktown	Ph (02) 9678 9669
Bondi Junction	Ph (02) 9369 3899
Brookvale	Ph (02) 9905 4130
Campbelltown	Ph (02) 4620 7155
Castle Hill	Ph (02) 9634 4470
Coffs Harbour	Ph (02) 6651 5238
Croydon	Ph (02) 9799 0402
Erina	Ph (02) 4365 3433
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Prices valid from 24th January 2014 to 23rd February 2014.

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SERVICEMAN'S LOG

Fixing smartphones & tablets can be tricky

Dave Thompson*

Repairing smartphones and tablets is now another string to my bow, although nowhere near as lucrative as I initially thought they would be. Parts availability, cost and long delivery times mean that the customer often just walks away and buys a new device.

I've mentioned before that I've now widened the scope of my business by accepting smartphones and tablets for repairs. However, deciding to repair these devices was the easy part. There were also other considerations, such as investment in marketing and advertising (so that people know that we now repair these items) and allocating money for any specialised tools or related hardware that were needed to get the job done.

On top of all that, I also had to learn new techniques and develop new skills. While everything superficially looks easy enough from a service/repair point of view, there are some aspects of phone and tablet repair that can be tricky to master.

Tablets and smartphones are basically computers that work pretty much the same as a desktop or laptop device. They have central processing units (CPUs), random access memory (RAM) and on-board storage, and run an operating system such as Windows 8, Android or iOS. However, that's where the similarities end because these gadgets are quite different from a repair standpoint.

First there is the size; phones and tablets range from small to tiny and when the smallest driver in your jeweller's screwdriver set is too big for the job at hand, you know there will be challenges. A decent magnifying lamp is essential kit and my LED magnifying headset almost never leaves my sweated brow when working on a smartphone.

iPhones and iPads (in fact, i-anything) are especially challenging to work on because they are over-engineered and where a simple plastic clip will suffice for Samsung, Apple will use half a dozen tiny screws, all different sizes and with a proprietary head pattern that requires a special driver to undo. OK, I'll admit to exaggerating that last sentence a little for dramatic effect but most i-devices are renowned for being tricky to disassemble.

Items Covered This Month

- Fixing smartphones & tablets
- The dusty Panasonic TV set
- Samsung Synmaster 226BW monitor
- Netgear 16-port switch
- Faulty air-conditioner

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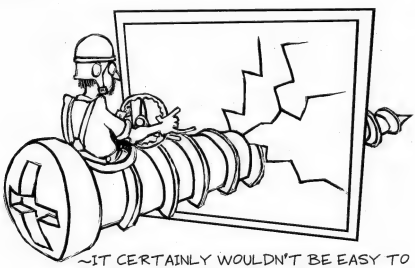
In fact, a photo taken before disassembly can be a Godsend weeks later when you get to putting it all back together again and you need to figure out just where those 20 tiny, all-different-sized screws go.

A wise investment is a screw guide for the different models of phones and tablets. These are plastic templates the same size as the device and have markings showing where the various internal components go and, more importantly, which screw goes where. Until one gets familiar enough with the gear so as not to need it, the few dollars these cost are well worth it.

In my case, the last thing I want to do is install one of the longer screws in a location where a shorter screw should go. In fact, I've seen many a laptop with lumps or holes in the top of the case because someone's brother-in-law/other relative (who knows all about computers) installed the wrong screws in various locations, only to find that they went right through the case when tightened down.

It certainly wouldn't be easy to tell a client that you've driven a screw through their LCD screen, so a great



~ BY ACCEPTING SMARTPHONES AND TABLETS, I HAD TO LEARN NEW TECHNIQUES AND DEVELOP NEW SKILLS.

deal of care is required when putting these devices back together! Tolerances are very tight, especially in phones where so much is packed into such as small space,

The criteria for repairing tablets and phones are also different than for a desktop computer. Indeed, the range of faults that can be repaired is rather limited and it can quickly become uneconomical to proceed. If we have to buy any major hardware component, such as a main board (known as a logic board in i-devices) or a replacement screen, the cost quickly blows out and most clients will red-flag the repair in favour of a new device.

Sourcing parts

Speaking of parts, a big issue here in New Zealand is sourcing them. Obtaining new parts directly from the manufacturer can be difficult, if not impossible, for some brands. What's more, those parts that are available are often disproportionately expensive, pushing the repair cost of an item over an already low "chuck-it-in-the-bin" threshold.

You might think that we could simply stock common parts for the most popular smartphones and tablets. However, the reality is that there are so many makes and models out there that we simply can't afford to have that much money tied up in screens and digitisers we "might use" one day. Besides, tablets and phones go out of fashion so quickly these days we'd probably end up with shelves full of unwanted parts gathering dust.

My opinion is that the manufacturers view these products more as consumable, throw-away items rather than as something intended to be repaired. The cost of spare parts and the often limited availability only serve to support this point of view.

As a result, the only repair options (apart from binning the device and buying a new one) are to use salvaged parts from previously written-off devices or, where feasible, import parts from overseas vendors. But even if the parts we want are available online, there is the issue of time; being stuck down here at the bottom of the world means that anything coming from south-east Asia takes about three weeks to arrive unless we want to pay silly money for expedited shipping which immediately puts the job back in the "too expensive" basket.

A recent example involved the digitiser for a Nokia Lumia smartphone which was listed for $US23.50 from a Chinese vendor. It wasn't a bad price given I couldn't source one locally but the estimated delivery time was 15-26 days – much too long for the customer to wait. If we forked out an extra $US39, I could have had it shipped quicker but it still would have taken 5-15 days, still an unacceptable wait for the customer (who only had one phone) and also making it too expensive to boot.

As an aside, we do offer a reasonable deal on a loaner phone but I've found that not many people take up the offer. The fact is, few people want to wait weeks for their phone to be repaired and while the time factor is less pressing with tablets, the same problems exist when it comes to obtaining parts.

On reflection then, repairing these devices hasn't been such a great add-on to our business – certainly not as much as I'd hoped. However, some people do want their devices fixed and so while only a few of these gadgets actually make it through to the workbench, we can and do fix them.

A typical repair

The following case illustrates a typical repair that I commonly do on both tablets and phones – repairing a broken digitiser. In almost all such cases, the device has been dropped, though occasionally I do see units that have been stepped on or sat on.

One recent case involved a near-new Samsung Galaxy Tab 10.1. Its owner had accidentally dropped it onto the garage floor as he got out of his car, breaking the digitiser. This is a common problem; most phones and tablets are wafer-thin and made of slippery materials and while some people buy a nice case to protect their device (and also make it easier to hang on to), many don't and end up losing their grip at the worst possible moment.

The Samsung Galaxy Tab 10.1 is a beautifully-made device and is a serious rival for Apple's iPad, arguably the industry standard for this type of device. When it comes to repairs though, the Samsung is generally the easier of the two to work on, although replacing a broken digitiser in either device presents a challenge.

The first thing I have to determine when the client calls is which part has actually broken. That's because most people claim they've broken the screen on their device, not realising that the screen and digitiser are separate entities. In my experience, broken LCD screens are relatively rare and it is usually just the overlying digitiser that has cracked, giving the appearance that the screen itself has cracked.

Fortunately, replacement screens and digitisers for most devices can be purchased individually, making repairs a lot cheaper than if they have to be purchased together.

The digitiser is a thin piece of very strong glass that overlays the LCD screen and is the part that gives tablets and phones their touch-screen capability. They must be manufactured under considerable stress because sometimes the smallest impact can result in a seriously shattered digitiser and yet in other cases, they can take a considerable shock and remain intact. It really is the luck of the draw and my advice is to avoid any kind of impact at all!

To determine what's going on, I ask the client if they can see the screen as normal underneath the cracks. If they can and the image isn't distorted or fragmented, then the LCD panel itself is probably fine and it is only the digitiser that has broken. On the other hand, if the screen displays gaps, lines or other artefacts, then the LCD has probably copped it as well and both parts will have to be replaced.

In fact, replacing both parts is actually preferable from my point of view because removing a cracked digitiser without damaging an unbroken screen underneath isn't easy. It certainly separates the men from the (cow)boys.

The problem is that the digitiser is held place using extremely strong double-sided adhesive tape and so removing it is quite a challenge. Getting it clear of the chassis without cracking the LCD screen beneath it or damaging the fine, decorative edge of the chassis itself is extremely difficult and this is where having the right tools makes a big difference.

In this case, the Galaxy Tab's screen was intact so only the shattered digitiser needed to be replaced. The owner wasn't bothered about the delay in getting the parts; he'd originally thought that he'd have to buy a new tablet, so he was over the moon when he found out that it could be repaired.

I ordered a new digitiser in from a vendor in China I'd used before. I then had plenty of time to get the old digitiser off while waiting for this part. If the digitiser is reasonably intact (ie, all the pieces are present and it's holding together), a heat-gun can be used to carefully heat around the edges, weakening the grip of the tape. This requires a lot of judgement, as too much heat can easily damage other parts while too little is ineffective when it comes to weakening the adhesive bond.

I use the hot-air function of my desoldering station so I can accurately adjust the temperature of the air. I also keep an infrared non-contact thermometer on-hand to make sure things don't get too hot. By using just the right amount of heat, the glue softens enough to allow a case-opening tool to be inserted between the digitiser and the chassis, after which the digitiser can be gently prised off.

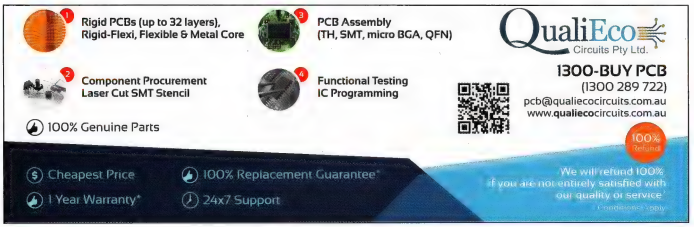
The trick here is to hold the tablet and use the hot-air gun to maintain the temperature around the area just ahead of the case opening tool, all while keeping forward pressure on the tool and upward pressure on the digitiser. Having three hands here is a definite advantage but with experience, it can be done with just two!

During this process, extreme care must be taken not to get anywhere near the LCD panel which lurks dangerously close to the digitiser. If the prying tool is pushed too far in towards the centre of the screen, pressure can be applied to the LCD instead of the chassis and the resulting crack as the screen breaks is a sound you definitely don't want to hear. Sticking close to the edge is a must but like any difficult job, it becomes easier after you've done it a few times (and accidentally broken the odd screen).

Another trap for young players is to be aware of the connecting straps linking the LCD panel and digitiser to the main PCB. There may also be more of these thin, flexible straps for things such as cameras running between the digitiser and the chassis, so just tearing around the outside with a case opening tool and heat-gun runs the risk of severing them.

Such connections are used a lot in tablets and phones and they are relatively fragile. While they can take a lot of flexing, they won't survive tight bends or nicks with a sharp-edged tool. A wise serviceman will always utilise resources such as Google and YouTube for advice and even repair walk-throughs uploaded by people who've already done these repairs and can warn of potential dangers.

The alternative way to remove a broken digitiser is piecemeal. If it has shards or pieces broken out of it, you can use a sharp, strong tool to gently pry between any gaps to lever other broken pieces free. Once one piece is out, you then move on to the next and so on, working your way around the edge. It pays to do this type of work



The Faulty Air-Conditioner & The Dusty Panasonic Plasma TV

How does a faulty air-conditioner cause a problem in a TV? K. P., of Dingley, Victoria, recently came across an unusual problem in a Panasonic TV set. Here's his story . . .

Sometimes the customer is right even though you are initially sure they aren't. It started out with a near neighbour who told me that her air-conditioner was blowing out a dusty mess each time it started. My reaction was one of disbelief and I began by explaining that this was not possible, as it was a split system with the fan totally isolated from the outside air. However, she insisted that it was making a mess and was getting worse.

What's more, if I didn't believe her, I could come and see for myself.

Well, it turned out that she was dead right. As soon as the unit was started, the normally tidy living room was immediately covered in dust. This was extremely puzzling and there just had to be something very unusual happening inside the wall fan/evaporator assembly.

Loosening the unit from the wall soon revealed that it wasn't exactly a "service-friendly" design. In fact, it quickly became obvious that fully removing it would result in a great deal of angst and time-consuming reassembly. So, after making a small gap, I used a high-power torch to light the suspect area and sure enough, it was full of gunk.

So where had it all come from? And how did it get to the fan? And then came "eureka"; the torch lit the surrounding area, revealing that a lazy tradie had punched a way-oversize hole in the gyprock plasterboard for the coolant pipes. The debris source wasn't so clear but it most likely came from a nearby concrete crushing plant, the airborne particles entering the roof and then falling down the wall cavity to the fan.

The gunk had adhered to all surfaces, so I painstakingly cleaned every blade of the barrel-fan with a cloth on the end of a screwdriver. Once that had been done, the holes around the pipes were sealed.

But how does this relate to a faulty flat-screen TV fault?

Well, my neighbour moved house a few months later, taking her large-screen Panasonic TV set with her. It had been a top-of-the-line set when purchased, so it came as a surprise when she told me that she was "going to give it away or send it to waste disposal".

Sure it had been run just about all day for years but it was still an excellent TV. When I asked why she was getting rid of it, she replied that the fans had become noisy. She obviously had fantastic hearing because when I checked the set out, only a slight noise was apparent to me at close quarters and it seemed to be quite acceptable.

However, she was adamant that it was too noisy, so I removed the set's

on a sheet on the workbench, as the small shards of the damaged digitiser end up getting everywhere and are very sharp. A pair of work gloves and eye protection are also vital, unless you enjoy digging splinters out of your fingers or eyeballs!

Fitting the digitiser

By contrast, fitting the new digitiser is simplicity itself; the only precaution is to make sure that the area is completely clean of old adhesive tape and bits of broken glass. If it isn't, you'll never seat the digitiser correctly and not only will it look rippled and horrible, it may not work correctly either.

I use a rag soaked in methylated spirits, turpentine or isopropyl alcohol to clean the surface of the chassis and to wipe any residue away. The new digitiser usually has double-sided tape already in place and all that is required is to strip the protective covering off before pressing it home. You only get one shot at it so I always trial fit it first, to make sure everything is where it should be.

Another precaution I learned the hard way is to test any new parts before finally fitting them. I once fitted a new digitiser to a device only to find that it was faulty, which meant that I had to remove it all again. Keeping the supplied heavy-duty screen-protectors on is also prudent as the digitisers are easily marked during fitting. Of course, you do have to remember to remove the inside one before sticking everything down!

It may seem a lot of time and effort taking on these devices but in business one must adapt to survive and I intend to be around for a while yet.

Samsung 226BW monitor

Regular contributor B. P. of Dundathu, Qld recently tackled a faulty Samsung 226BW monitor he scrounged from a mate. Here's his story . . .

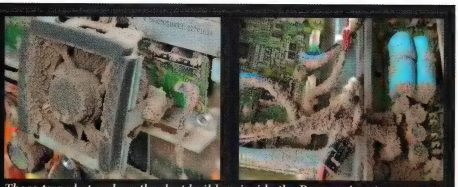
I'm a regular visitor to my mate Tim's computer repair workshop and on one occasion, he passed a Samsung SyncMaster 226BW wide-screen monitor on to me. Apparently, the customer had decided not to have it repaired, despite the fact that it appeared to be in excellent condition.

When I got it home, I immediately decided to have a look at it. I plugged it in, pressed the power button and waited for something to happen. The blue backlight on the power switch came on but there didn't appear to be anything on the screen, at least not initially.

Closer inspection of the screen then revealed that the screen-saver was visible but it was so dull that it was almost impossible to see! This indicated that the inverter was not supplying power to the backlighting.

This monitor is similar in construction to the 740N monitor I'd previously repaired but is somewhat easier to dismantle. First, with the monitor face down on a cloth on the table, the stand is removed by undoing three screws and then sliding it out. That done, the three screws along the bottom of the monitor are removed and the monitor is then turned over and the front moulding prised off.

It is then turned back face down and the plastic back-shell lifted off. A shield on the left-hand side is then removed, followed by the four



These two photos show the dust build up inside the Panasonic set.

back and was stunned by what I saw. Even though her house had always been clean, the air-conditioner at her old place had very effectively distributed the airborne dust from the crusher plant to the TV and everything inside the set was absolutely covered with it.

It was literally the worst mess I've ever seen inside a TV set.

The challenge now was to clean the set up and I began by taking it outside and blowing away most of the gunk using and air-compressor. Of course, I pre-tested the airflow from the nozzle first to determine how close I could get without causing component damage. This was then followed up with a dust down using a soft paintbrush and then a final quick blast from the compressor.

That done, I gave the set a thorough visual check and made sure that the fans were perfectly clean. I then left the set with its back off for a full day to allow any moisture from the compressor to dry out.

On switch on, everything was perfect. It would be easy to to replace the fans but they're quiet again so that appears to be unnecessary. And so, a perfectly good set was saved from landfill just by giving it a good clean-up. It should have many years of useful life ahead of it.

high-voltage connections to the backlighting and the front panel connector. This then allows the metal shell housing the two boards to be lifted up high enough to enable the removal of the screen connector.

Next, I turned over the metal shell and removed the three screws and the small clip securing the power board and lifted it high enough to disconnect it from the video board. And when I turned the power board over, I could see three "dead" electrolytic capacitors: two 820µF 25V and one 330µF 25V. The domed bulges on the tops of these capacitors were a dead give-away that they had failed.

Next, I ran a few basic tests on the power board. I expected the pico-fuse to be open circuit, which would cause the inverter to fail to power up, but it was still intact. This made me think that there might be some fault on the power board that I would not be able to locate, meaning that it would have to be replaced. This monitor is newer than the 740Ns I'd been repairing previously and has a much larger power board. As a result, it would almost certainly be more expensive, so I was hoping that I wouldn't have to replace it.

After replacing the three faulty electrolytics, I inspected the board closely and I could see quite a few dry joints. They were particularly bad on U302 and U303, which are 4511 ICs. The dual-diode for the inverter supply also looked suspicious.

As a result, I touched up all these faulty connections and reworked the connections on the three transformers and the power FET for good measure. I then re-connected the power board and set the monitor up for testing. When I pressed the power button, up came the screen-saver. Whew!

I then re-assembled the monitor, connected it to a PC and took a short break while I waited for the computer to boot up. When I returned, the monitor's screen saver was on, indicating that there was no signal.

This particular monitor has two inputs: a DVI input and a VGA input. I'd used the VGA connector because the test computer didn't have a DVI output. Pressing a button labelled "Source" on the monitor's front panel allowed me to select the correct signal source and I was then greeted by the Windows desktop.

Satisfied that the monitor was now working correctly, I then took it inside and showed it to my son who had been asking for a wide-screen monitor for some time. We connected it to his computer using a DVI cable, selected a DVI signal source and then, when the computer booted, went into the Windows 7 settings and set the resolution to 1680 x 1050 (the native resolution of this 22-inch wide-screen monitor).

This was a big improvement over the 1280 x 1024 resolution that he'd previously been using on his 17-inch Samsung 740N monitor and was just the shot for the graphics programs he works with.

Netgear 16-port switch

With the monitor under my belt, I decided to take a look at my home network. We'd been having a few unusual problems with this for a couple of weeks and after some troubleshooting, I eventually traced the problem to the network's 8-port switch.

The easiest solution was to simply replace it, so I retrieved a Netgear 16-port switch I'd scrounged some time ago and connected it into place. Unfortunately, this new unit turned out to be completely dead so I then substituted a Linksys 16-port switch that had come my way at the same time.

This time, it all worked, so that solved the network problems. But what was wrong with the 16-port Netgear unit? It was time to see if if I could get it working again.

First, I removed the front panel and then the lid – a total of seven screws in all. This revealed the inner workings of the unit which consists of four separate PCB assemblies: two in a piggyback arrangement, another on the back of the front panel and finally the one that I was interested in, the power supply board. The latter supplies two 3.3VDC rails to the piggy-backed PCBs via a 4-conductor cable with a plug at each end.

The power supply PCB is a typical switchmode unit and is easily removed from the case by removing four screws and two plugs, one plug at the AC end and the other at the DC end. With the PCB removed from the unit, I started by checking the ESRs of the electrolytic capacitors and all were OK

Intermittent fault in a Vietnam-era mortar locating radar

Nearly 50 years ago, G. C. of Briar Hill, Victoria was a soldier in Vietnam. Here's how he tracked down a puzzling fault in a vital piece of gear known as a mortar locating radar . . .

The Serviceman's Log article on the Tektronix Model 422 Oscilloscope in the June 2013 issue brought back many fond memories for me. I was an electronics tradesman (a radar mechanic) in the Australian Army during the 1960s and oscilloscopes and the vacuum tube voltmeters (VTVMs) were the primary diagnostic tools for repairing radar sets. And the oscilloscope that I used was a Tektronix Model 422.

The radar set that I worked on at the time was a mortar (bomb) locating radar designed for the US Marine Corps. To be more precise, it was an AN/KPQ1 Mortar Locating Radar, affectionately known as the 'Q1'.

The Q1 had five antennas which were used sequentially and the returns (ie, the strength of the signal reflected off the mortar bomb during flight) from each of the antennae were compared to each other and allowed the antenna assembly to be driven to follow the bomb. The angles of the antenna assembly (horizontal compared to grid north and the vertical angle) and the range to the bomb were fed into a computer which, after eight seconds of "tracking" data, could be used to determine where the bomb had come from.

The computer used a combination of analog and digital computing techniques and the entire radar set was powered by a diesel generator set (gen-set) producing 110V, 3-phase at 400Hz. The 400Hz supply allowed for the use of much smaller (and lighter) electric motors to drive the antenna assembly than a 50Hz or 60Hz supply would. In addition, it allowed for smaller motors in the various fans used to cool the six modules of the radar set.

The gen-set was driven by a Bucknell single-cylinder diesel motor and the vibration this motor produced played havoc with its own mechanical items (the fuel pump, in particular) and the regulation circuit of the generator. The gen-set's field control device (a germanium power transistor, from memory) would go short circuit and the 110V supply would instantaneously rise to over 300V. As can be imagined, the radar set didn't like this one little bit and it would be out of action for several days while I and my fellow radar mechanics tracked down and repaired the damage.

Parts for the Bucknell gen-set were very hard to obtain in the mid-1960s and so a different type of gen-set was sourced from Australia (you may have guessed by now that I was in South Vietnam at the time). Several new gen-sets subsequently arrived just before Christmas and we put them to use immediately; well almost immediately.

The original Bucknell gen-set had open screw terminals to accept the power lead connections. The power lead was terminated in a triangular potted block with each of the four wires separated and colour coded. Basically, the radar operator had to make sure he connected each coloured wire to a matching coloured terminal on the gen-set.

In order to install the new gen-sets, our first job was to cut off the potted blocks (we had three radars) and connect a new 4-pin plug to each of the power cables. As a result, we opened the power panel of one of the new gen-sets and checked the colour coding of the wires to it's output socket, then wired all our power cable plugs to match.

The new gen-set had a VW Industrial petrol motor as its drive source and the US-supplied gasoline was heavily leaded. The result was that the spark plugs "carboned up" after about 48 hours of continuous running, no matter how hard our vehicle mechanics tried to tune the petrol motors. Fortunately, we had four of the new gen-sets, which meant that a swap-over could be implemented while the spark plugs in the off-line unit were cleaned and reset.

That's all by way of background and everything worked fine until one of the radars developed a fault. There was very little hostile mortar action at the time but the radar sets were run continuously, just in case. The sets were tested once a day, just to make sure they were ready.

A test of the Q1's tracking capability involved "locking-on" to a passing helicopter or transport aircraft. Anyway, a fault pattern developed in one of the radars; every now and again, the radar would "drive off" the target aircraft and cease tracking. This puzzled the operators and they (rightly) demanded that we "fix" the problem.

My boss and two fellow radar mechanics subsequently spent many hours trying to diagnose this fault. It so happened that the other two Q1s had been taken off line for other problems (obtaining parts for the radar sets was also difficult at the time), so it was imperative that this particular radar set be kept working.

What was puzzling was that the "fault" would mysteriously fix itself and that meant we had an intermittent fault to find.

One night, I got the task of working on it. My boss and one of the other radar mechanics had worked on the Q1 all afternoon and so, after the evening meal, I took over trying to diagnose the problem. There were no aircraft flying around after dark but there was a steel radio mast about 5km away and this was perfect for displaying the fault. When the fault wasn't there, the antenna assembly would rock-solidly lock-on to the

except for C3 (47µF 25V) which was a little high. However, I didn't think that it was unreasonably high for such a low-value capacitor, so I moved on to checking other components.

After testing Q1 (a FET) and CR1 (a dual diode), I then checked the small diodes and I could find nothing wrong. I then decided to replace IC1, which is a UC3843AN Current Mode Controller but this proved fruitless, as the unit was still dead afterwards.

mast. And when the fault was present, it would loose the lock.

As previously stated, each of the five antennae was used in a sequence. The microwave power was switched to each antenna by a rotary switch and a magnetic pick-up on the switch body was used to trigger the transmitter once the appropriate waveguide (to the antenna about to be used) was open.

Basically, a steel pin on the rotational part of the switch would trigger the unit when it passed the end of the pick-up. And as can be imagined, it was quite important for the rotating switch to be in the right position when you are dealing with a 140kW pulse of microwave energy.

We had already determined that something was happening to the timing of these pulses but we couldn't determine what it was that would cause the radar antenna assembly to be driving away from the target. The valve-based circuit we were concentrating on had to amplify the pulses and square them up for their leading edge to trigger the magnetron transmitter. The circuit also had to create five non-overlapping monostable pulse channels which were used to "gate" the returned echo (signal) to the appropriate mixing and strength comparison circuits. These circuits, in turn, produced the drive voltages to operate the two antenna drive motors in the horizontal and vertical planes.

Our theory was that the timing of the channel pulses was being changed somehow, so that the returned echo was either being gated to the wrong comparator or gated to more than one comparator at a time.

That's where the Tektronix Model 422 Oscilloscope comes into the picture. It had been set up to trigger on the pulses from the magnetic pick-up, so that we could observe the waveforms all the way through to the comparator circuits. There was also a second magnetic pick-up on the rotary switch and it was used to indicate the start of a sequence. It provided one pulse for every five

from the other magnetic pick-up.

Fortunately, by chance, I connected the scope's trigger to this latter pulse instead of the pick-up to trigger the transmitter and got a strange result – the channel pulses were occurring in the reverse order. Basically, the channel two pulse occurred before the channel one pulse, the channel three pulse occurred before channel two and so on.

When I saw this, I could hardly believe what was happening; I was so used to observing the correct position of each of channel's pulses as I moved the probe to each channel in turn, that having the pulses "move" backwards was mind boggling. I moved the probe from channel to channel for quite some time to make sure I wasn't dreaming before eventually coming to the conclusion that the rotary switch had to be running backwards. I couldn't understand why it would be doing this but to check my theory, I swapped two of the wires on the 3-phase motor driving the rotary switch and bingo, the antenna assembly stayed locked on to the radio mast.

I raced over and got my boss and told him that I knew what the problem was but I couldn't explain why it occurred. I say "raced" but it wasn't quite like that. I had to get clearance from the Task Force Headquarters to allow me to move from one area to another after dark, otherwise you could get into serious trouble, not the least of which was to be shot at by your own side.

We thought the problem over and suddenly the penny dropped; the problem must have occurred after a changeover to one of the new gen-sets. Their phase rotation based on the colour of their wiring hadn't been standardised; some of the new gen-sets had their phase rotation correct for the Q1 radars but at least one didn't. As a result, using a generator with the wrong phase rotation was the cause of the radar's antenna assembly driving away from the target lock-on and this also explained why the fault subsequently mysteriously disappeared, ie, at the next generator changeover.

We hadn't associated this changeover with the problem, as that function was always handled by the radar operators and they hadn't realised either. Standardising the wiring on our four gen-sets cured the "fault" and we also advised the generator purchasing people in Australia of the problem so that future units would also be standardised.

So that was the answer to a very puzzling problem. After 46 years, I can still visualise the AN/KPQ1 Mortar Locating Radar's five channel pulses on the screen of that Tektronix Model 422 oscilloscope.

Feeling somewhat exasperated by now, my next step was remove C8 (10nF greencap) and electrolytic capacitor C3 from the PCB and check them further. C8 tested fine and C3 was well within tolerance at 44µF but, as previously stated, its ESR was a little high.

I reinstalled C8 on the PCB but decided to replace C3, even though it didn't seem to be too far out of spec. I then reconnected the power supply

and tested the unit again and it now worked, so C3 had been the culprit all along. It would appear that this electrolytic capacitor in this particular location is highly critical and the slightly high ESR reading was enough to prevent the power supply from working.

This also indicated that the original UC3843AN IC was quite OK. However, I wasn't going to go to the trouble of removing the new one and refitting the old one just to verify this. It simply wasn't worth the effort for the small cost of the IC and if the old one did prove to be faulty, it would then be necessary to remove it and refit the new one again.

With the power supply now working again, I reassembled the unit and reconnected it in place of the Linksys unit. I then checked the network out and found that it was working correctly so that's another piece of "junk" that has been saved from landfill.

I didn't bother swapping the Linksys unit back in. Instead, I simply left the Netgear switch in place and put the Linksys unit away as a working spare.

Faulty air-conditioner

A. F. of Kingscliff, NSW recently tackled an unusual fuse fault in an air-conditioner. Here's what happened . . .

I enjoy repair work, mainly because of the challenge and the fact that I never know what I will find when I accept a job. Sometimes though, when a repair is done, I'm left in a situation where I'm not exactly sure why the fault occurred. And that leaves me feeling uneasy that the fault (and possibly an irate customer) might return.

That was certainly the situation with a faulty air-conditioner I recently encountered. It had a blown fuse and in all such cases, I automatically assume that there is probably a faulty component somewhere which caused the fuse to blow.

The customer assured me that the unit had functioned for a few seconds immediately after start-up, during which time the flaps on the wall unit half opened. At that point, everything stopped and the air-conditioner was completely "dead".

My initial investigations revealed that this was a split system, with the compressor unit mounted outside in the garden and the evaporator/condenser unit mounted on the wall in the living room. The wall unit would not respond to the remote control and a quick check of the meter box showed that the the circuit breaker hadn't tripped.

Next, I removed the inspection cover from the side of the compressor unit to reveal the mains terminal strip and found that there was approximately 230VAC on the Active terminals. From there, four cables enclosed in conduit, headed off under the house, in the direction of the wall unit. So the next port of call would be the wall unit.

Removing the covers on the wall unit was easy. Once they were off, I could see that the four cables from the compressor unit were connected to a small PCB which was sandwiched between the motors and the end casing. It wasn't possible to see much of this board, so I turned the power off, marked each connector to ensure it went back to its original position, and extracted the board from its hidden location.

It didn't seem to be particularly complicated and consisted of a mains transformer to step down the voltage to the circuit board, a relay which was connected to the 230V and sundry other parts. I took it outside to look for burnt or deformed components and a 2A M205 fast-blow fuse immediately caught my eye. A quick check with a meter confirmed that it had blown.

The job now was to track down the faulty component that had caused the fuse to blow. I soon spotted a large metal oxide varistor on the board which appeared to have a large black crack across it. I immediately de-soldered it but my multimeter did not show a low reading.

When I took a close at it through a magnifying glass, it became apparent that the "crack" was raised above the surface of the MOV. So the crack wasn't a crack after all and when I rubbed it with my finger, it rolled off the surface in the form of a line of glue. I re-measured the MOV and it seemed OK so I refitted it.

Next, I checked the other components but could find no reason for the fuse to blow. Eventually, I ran out of things to check, so I replaced the fuse and refitted the board to the wall unit but with no plugs connected. I then switched the power back on and hurriedly ran inside to check the board.

There was no apparent drama, so I now powered down the mains and fitted the connector for the ON/OFF circuit board. Again I applied power without drama and found that I could now operate the ON/OFF LED with the remote control so I powered the unit down again and plugged in the connector for the flaps. The flaps could now be made to open and close in the normal manner, so it was time to test the remaining functions in stages.

I reconnected the left/right airflow stepper motor and this also worked OK. Likewise with the centrifugal fan motor and finally the relay which caused the compressor motor to run. At this point, the whole system was working again and blowing cold air.

So what had caused the 2A fuse to blow? I couldn't find the reason but my guess is that it was the accumulation of the fuse being some 10 years old, the tin-plated copper fuse wire oxidising and the fact that it was mounted vertically and was subjected to vibration from several nearby motors. Together, these factors gradually weakened the fuse mechanically until eventually it blew.

The unit has operated without fault for some six months now but it's impossible to say if or when the fuse will fail again. Hopefully, it was just mechanical failure due to age and vibration. SC

Servicing Stories Wanted

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Audio decibel meter uses logarithmic converter

This circuit converts an AC input signal in the range of 3μV to 400V (in three ranges) to produce a voltage equal to the decibel figure of that signal (dBV; ie, 1V = 0dB) as a voltage at the output, scaled as 1mV = 1dB. So in other words, if the input signal is -10dBV, the output will read -10mV. Most meters will read the average voltage and thus give the average decibel level of the input signal.

It works as follows. Rotary switch S1 selects one of three ranges. Position 1 is for signals in the range of -110dBV (3μV) to -48dBV (4mV), position 2 for signals of -56dBV (3mV) to +2dBV (1.3V) and position 3 for signals 0dB (1V) to +52dB (400V). In positions 2 & 3, the input signal is attenuated by resistive/capacitive dividers to suit the following circuitry while in position 1, the signal is amplified by IC1.

In each case, the input impedance is set to 1MΩ; in the case of positions 2 & 3, this is determined by the divider resistor values while for position 1, this is achieved by means of bootstrapping the input of IC1. This means that the signal from its pin 6 output is coupled back to its pin 3 input, such that most of the current required to drive this input actually comes from the op amp's output and not the signal source. IC1 is configured for a gain of 100.

The second pole of rotary switch S1b then selects the appropriate amplified or attenuated version of the input signal to pass on to the input of buffer op amp IC2. This then feeds the signal to IC3 which is configured for a gain of 20, giving an overall gain of 2000 when S1 is in position 1, 6.33 in position 2 and 0.02 (ie, 1/50th) in position 3.

The amplified signal is then rectified by op amps IC4b and IC4a which are configured as a precision rectifier. The output voltage of this rectifier is negative and is equal in magnitude to the input voltage (ie, the output of IC3a). Potentiometers VR2 and VR3 are used to trim out any offset error in IC4a and IC4b, so that with no signal, the output is as close to 0V as possible.

This negative rectified voltage is then applied to the logarithmic converter which consists of PNP transistors Q1 & Q2 and op amps IC5a & IC5b. This takes advantage of the well-defined exponential relationship between the base voltage and collector current in a bipolar transistor and its output is a voltage, which is the natural logarithm (ie, log base e) of the input voltage.

However, as the name suggests, decibels use a base-10 logarithm. Since the input is in volts, while power is proportional to the square of voltage (decibels are a measure of power), the actual formula to calculate dBV is $20\log_{10}V$ where V is the input voltage.

Luckily, as anyone who has used a slide rule can tell you, converting between different base logarithms is simply a matter of applying a scale factor. In this case, it is a scale factor of 0.4343 or $1/\log_e 10$. This ratio is set by the ratio of the 100kΩ resistor at the collector of Q2 to the 200kΩ resistor at the collector of Q1 and 100kΩ series trimpot VR3.

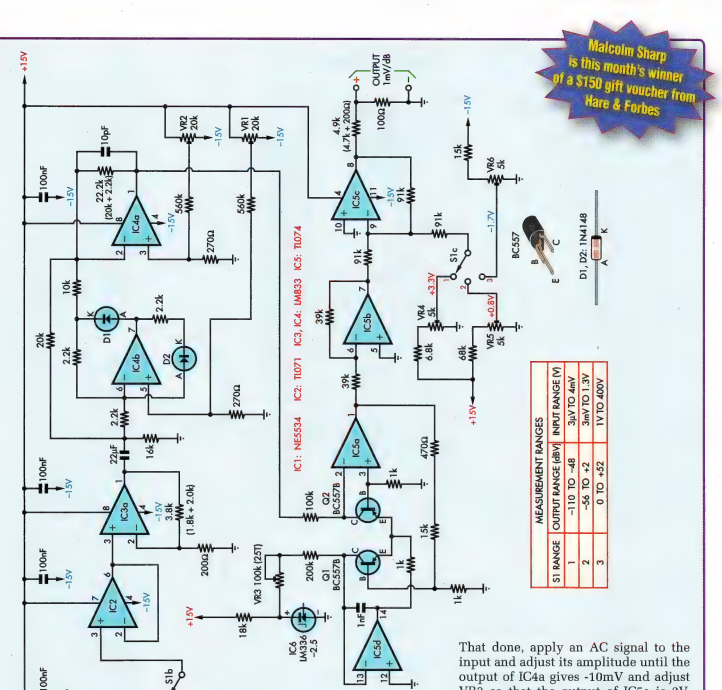
Thus, with VR3 adjusted to give the correct ratio, the output of IC5a is scaled to be a base-10 logarithm rather than a natural logarithm. So for example the output will be -2V for an input of -10mV, -1V for an input of -100mV and 0V for an input of 1V.

Reference diode IC6 is used to provide temperature compensation for the logarithmic converter. This is necessary because the base-emitter voltages of Q1 & Q2 vary with temperature. IC6's output voltage varies in a similar manner and so these tend to cancel out.

The output of the logarithmic converter is inverted by IC5b and then inverted again by IC5c, which also adds a fixed voltage to it, from the common terminal of S1c. This means that the correct number of decibels are added to the result to compensate for the selected input amplifier/attenuator.

Finally, the output voltage is divided by a factor of 50 (ie, 1000 ÷ 20) by the 4.9kΩ/100Ω output divider to give a result with a scale of 1db = 1mV. In other words, we need a 20mV change in the output voltage for each 1V change in output of the logarithmic converter, as per the formula provided earlier.

To set the unit up, first adjust VR1 and VR2 to get 0V at the output of IC4b and IC4a with no input signal.



That done, apply an AC signal to the input and adjust its amplitude until the output of IC4a gives -10mV and adjust VR3 so that the output of IC5a is 2V. VR4-VR6 are then set to give the specified voltage at each wiper while VC1 & VC2 are adjusted to give the best square wave at the output of IC2 for a square wave input in each range.

When set up correctly, at room temperature, output accuracy is ±0.5dB over a 150dB range. Below -106dB, the output is likely to read high.

Note that since measurement averaging is done by the meter used to measure the output, which is after the log conversion, accuracy will depend on the shape of the waveform and whether the meter is an averaging or true RMS type.

Malcolm Sharp,
Berala, NSW.

Cheap USB-powered PCB drill

A USB keyboard vacuum cleaner from a bargain store (£1 Shops in the UK) can be modified to make a handy PCB drill. First, untwist and discard the nozzle, then remove the dust filter and O-ring. Next, open the casing by removing three screws and trim off the support for the dust filter.

Now remove the impeller and trim off the vanes. That done, push a 6mm length of sleeving over the shank of the twist drill bit and push the drill bit into the 2mm hole in the remains of the impeller.

A piece of 1.6 mm heatshrink tube can be used to build up the drill shank if it is a loose fit. Check that the drill bit runs true and concentric and then reinforce it with epoxy adhesive. As a bonus, these little vacuum cleaners have a white LED and two speed settings.

The rear bearing of the motor may be plastic so use only light drilling pressure and a 0.7mm or 0.8mm drill; maximum 1mm. The transistor can be removed from the internal

PCB if you only require single speed operation.

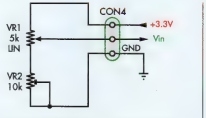
John Russull,
Tottenham, UK. ($40)

Minimum speed adjustment for Induction Motor Speed Controller

This small modification to the external speed control pot on the Induction Motor Speed Controller (Silicon Chip. April & May 2012) was made to give better operation with a roof-mounted evaporative air-conditioner. This has a Fasco 809454QVB-A14 750W motor.

The problem with the external speed control pot was that members of the family had a habit of running the motor too slowly. This resulted in ineffective cooling, both to the home and the motor. It also resulted in an annoying "cogging" noise from the motor.

To eliminate this problem, the external speed pot circuit was modified to incorporate a minimum speed trimpot. Now, no matter how low the main speed control is set, it will never go below the minimum setting.



The modification involves replacing the 10kΩ external potentiometer with a linear 5kΩ potentiometer and wiring it in series with a 10kΩ trimpot, as shown in the diagram.

Setting up is easy. Firstly, measure between the top of the new speed pot and the bottom of the trimpot and adjust the trimpot to obtain a total resistance of 10kΩ (ie, the same resistance as the original circuit). Connect the assembly to the speed controller, set the main speed pot to its minimum speed position and start the motor. Then adjust the trimpot to the minimum speed you require.

The maximum speed is still maximum when you turn the main speed pot fully clockwise but the low speed will not go below your pre-set speed when turned to its lowest position. I find I can adjust it from about 10% of maximum speed to 100%. I have set mine to a minimum of about 45% which gives a gentle breeze on low and a hurricane on high!

Peter Clarke,
Woodcroft, SA. ($40)

PICAXE-based garage door controller

This garage door opener project uses a car windscreen wiper motor driving bicycle sprockets and a chain to automatically open and close a garage roller door.

The PICAXE14M2 (IC1) monitors a number of input devices. A remote control circuit can be connected to pins 6 & 7 while the pushbuttons connect to pins 4 & 5. Limit switches S3 & S4 (limiting the door travel at top and bottom) connect to pins 10 & 11. The door motor "stall" detector circuit compares the voltage levels on pins 3 & 12 and these are configured as analog inputs.

The pushbutton and limit switch inputs have pull-up resistors enabled inside the PICAXE microprocessor, eliminating external resistors. The upper and lower limit switch inputs include optocouplers to reduce electrical noise transfer from the wiring. These limits are wall-mounted microswitches operated by a semi-ridged plastic strip attached to the door. The open and close buttons mount on the control box and require "snap action" contacts.

The stall detector circuit uses the sense input on pin 12 to measure the voltage drop across a 0.22Ω resistor in series with the door motor. This voltage is compared with the voltage level at the "set" input (pin 3) which is set by trimpot VR1.

The trimpot is adjusted so that the door closes normally but stops and then reverses if obstructed. There is

a short delay while the motor starts, before the "sense" input voltage is checked.

The PICAXE14M2 (IC1) drives a number of output devices. The open and close relays are controlled via transistors Q1 & Q2, driven by pins 8 & 9. The LED courtesy lamp is controlled via transistor Q3 and pin13. An ICSP header is included to program the microprocessor using pin 13 as the serial output and pin 2 as the serial input signal.

The open relay (RLY1) and close relay (RLY2) reverse the motor voltage to control direction. While the door is stopping, the relay contacts short the motor terminals to act as a brake. The prototype unit used SY-4050 relays from Jaycar with 12V DC coils and 10A contacts.

The courtesy lamp stays on for three minutes each time the garage door opens or closes and contains a series string of three high-intensity white LEDs and a 150Ω current limiting resistor. The white LEDs each give a narrow beam of light that is best reflected off the garage wall.

The door operator is powered by a 12V car battery or sealed lead acid battery (SLA) which is required to supply around 5A to the motor. While the circuit shows a remote control receiver, we should point out that any garage door controller ideally should have a rolling code remote (see SILICON CHIP, August & September 2009).

The battery should be trickle-charged with a 14-16V DC supply. Many 12V DC (300-500mA) plug-packs will provide sufficient voltage when lightly loaded. Select a suitable 5W series resistor to keep the fully-charged battery under 13.8V DC. The in-line 10A fuse protects the motor should a fault prevent the "stall" detector working. Motor surges on the power supply rails are decoupled using diodes D1 & D4 and their associated capacitors.

Finally, the PICAXE14M2 (IC1) microprocessor is programmed using the (ICSP) header and a special PICAXE serial or USB cable to download the *gdopener_14m2.bas* program. This software will be available on the SILICON CHIP website.

Ian Robertson,
Engadine, NSW. ($60)

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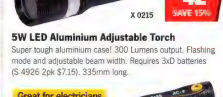

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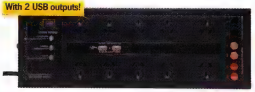

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Colour	Part	1m	5m Roll
Warm White 3528	X 3200	$12.00	$48.75
White 3528	X 3202	$12.00	$48.75
Warm White 5050	X 3208	$22.50	$100
White 5050	X 3210	$22.50	$100

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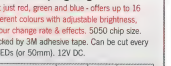
Two chip sizes - 3528 (medium brightness) or 5050 (high brightness). Backed by 3M adhesive tape and encased in flexible plastic. Can be cut every 3 LEDs (or 50mm). 12V DC. **Important: To maintain weatherproof seal, end caps must be fitted on cut edges.**
X 3225 IP65 3528 end caps: $2.50pr
X 3224 IP65 5050 end caps: $2.50pr

Colour	Part	1m	5m Roll
Warm White 3528	X 3204	$15.00	$67.50
White 3528	X 3206	$15.00	$67.50
Warm White 5050	X 3211	$28.00	$125
White 5050	X 3212	$28.00	$125



RGB LED Strip Lighting

Not just red, green and blue - offers up to 16 different colours with adjustable brightness, colour change rate & effects. 5050 chip size. Backed by 3M adhesive tape. Can be cut every 3 LEDs (or 50mm). 12V DC.

Type	Part	ea (m)	5m Roll
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RGB IP65 Outdoor	X 3214	$32	$144

Add-Ons	Part	ea
Controller & Remote	X 3218	$14.95
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This ultra compact ratchet kit is ideal for working in tight spaces inside equipment. Supplied with: • #1, #2 phillips • #1, #2 pozidrive • T10, 15, 20 torx • 4, 5 & 6mm flat blade • 5, 6, 7, 8, 9, 10mm 1/4" drive hex sockets.

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T 2630 Iron & Cartridge.

125W Iroda Portable Gas Cartridge Tool

• Powered by refillable butane cartridge • Totally wireless operation - No need to run extension leads • Super tough design will last for years • Easy to light, one-click piezo ignition • High reliability long life tips
• Blow torch & soldering iron in one
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This kit version of the T 2630 includes hot air tip, heat deflector, additional gas cartridge, solder, sponge and hard carry case (T 2631). Powers on for up to 4 hours from a full tank of gas!

T 2631 Full Kit

To buy these parts separately would set you back over $200!

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Water & Dustproof (IP67) True RMS Multimeter

Top of the range! Ideal for marine & mining technicians. • True RMS measurement • 40MHz freq. counter with bar graph • Max/min recording • Capacitance to 40mF. • Temp measurement • 10A current range • Auto power off • Includes thermocouple • Data hold.

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Q 1026A

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365x266x165mm	T 5050	$98.50	$78
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Colour MaxiMite Kit

(SC September '12) The new colour maximite is here! Upgraded with colour VGA output, stereo audio synthesiser, real-time clock, Arduino compatible connector and 20 more I/O lines. A powerful programmable computer for innumerable logging, monitoring and switching projects. Note: SD card not included.

Original MaxiMite Still Available	
K 9550 Maximite BASIC SD Computer	$69
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'Classic-D' Amplifier Module Kit

(SC November '12) A rugged and reliable Class-D audio amplifier producing up to 250W into 4Ω. This high efficiency, high power design is ideal for building into any audio amplifier design. Class-D amps are commonplace amongst consumer equipment. Low distortion <0.01%. Based on the IRS2092 audio amplifier chip.

K 5182 Optional speaker protector	$19.95

K 6009

Take amazing stop motion photos with your camera!

(SC Jan '09) Flash Camera Trigger Kit. Take pictures at precise moments from 1ms to 9.99s after a trigger. Triggering can be from the included electret mic or other sensors like a PIR detector, light-beam interrupter, or sensor switches (not included). Requires 9V battery.

K 6011

Beam Trigger Kit For K 6009

(SC July '09) Connects to the contact input of the K 6009 to provide a trigger when the beam of IR light is broken. 9V or 6xAA battery powered.

K 1128

Electronic Bellbird Kit

(SC Dec '13) A great starter project for kits to learn about electronics. Mimics the musical sounds of a real Bellbird with a decorative LED chaser light. Includes button cell battery.

K 6021

High Power Ultrasonic Cleaner Kit

(SC August '10) Build this large, heavy duty ultrasonic cleaner and blast away grime from virtually anything, using just water & a little household detergent. Sensor can be dunked into a bucket of water for cleaning large items. Great for car parts, bric-a-brac and more! Requires 12V DC 2.5A plugpack, M 8937 $29.95 (fitted with 2.5mm tip).

K 2920

Cut Office Power Consumption

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(SC January '09) Monitors your PC's USB port and automatically turns all your gear on and off as required. No need to crawl under the desk to disconnect devices!

K 6140

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(SC October '08) A handy timer module designed to accept a trigger input from a rising or falling voltage. When triggered the timer can switch devices on for any period between 0.1s and 16.5 minutes.

K 6047

Adjustable from 5s to 1 hour.

Mains Timer Kit For Fans & Lights.

(SC August '12) This small module can save power by switching off fans or lighting after a period between 5s and 1 hour. It can also be hooked up to a mains rated push button for a timed manual activation. 5A/1250VA max rating. Note: must be installed by a licenced electrician in most states.

K 1143

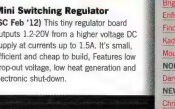
GPS Boat Computer Kit

(SC Oct '10) Tells you exactly where you are - never get lost at sea again. Also shows speed and heading - plus it will navigate you back home - or to that secret fishing spot! It even displays fuel consumption, along with a host of other vital information.

K 5136

2x20W 12V Amplifier Kit

(SC May '10) This compact stereo amp module puts out 2x20W RMS into 4Ω and is 12V powered (SLA battery or plugpack). Distortion typically <0.03%. Bass & treble controls. Great for mobile use in a caravan.



K 6340

Mini Switching Regulator

(SC Feb '12) This tiny regulator board outputs 1.2-20V from a higher voltage DC supply at currents up to 1.5A. It's small, efficient and cheap to build. Features low drop-out voltage, low heat generation and electronic shut-down.

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Thinking *inside* the box!

by Stan Swan

Cartoon by Barney Walker

Many modern electronic components sell very cheaply and some circuits – even using microcontrollers – need just a single supply around 3.3V. However, cases, switches, mounting hardware and battery holders can be disproportionately costly – often more than the high-tech electronics within! Here's a neat, low-cost solution.

Given the cost of project cases, if you're on any form of budget it's often tempting to leave the project "air insulated", ie, with no case. But damage to exposed connections and flying wires may be a risk. And it certainly doesn't look too professional, either.

Because many projects have only a few components – a microcontroller and little else in some cases, quite small cases can be used. So here's a different approach: use a switched battery box to not only hold the battery... but hold the project as well!

It's a cheap solution, with battery boxes selling for just a couple of dollars or so. It's educationally beneficial too, as it will prompt builders to the sort of compact layouts and neat wiring that are required of today's designs.

Switched battery boxes come in a variety of sizes, most often to suit AA and AAA cells. Two, three and four cell sizes are relatively common but others are available. The common ones can be obtained from most electronics

By removing the inter-cell ribs a circuit board or even a small protoboard can be fitted in the space made available. Run a 3.7V lithium or (better still) a 3.2V LiFePO4 battery and you have a self-contained project, with battery and on/off switch. The PCB here is cut from a Jaycar HP9558 experimenter's board.

retailers and also on-line.

They've traditionally been black, but transparent and coloured ones are also available. A summary is shown below.

Circuit board

The idea is to replace one or more cells in the battery box with a small PCB or other board containing the circuitry. This may or may not require the removal of inter-cell ribs to fit larger boards.

Obviously, you need to determine the size of circuit that can fit into the switched battery box. This also depends on the size and number of cells it was originally intended for.

Rechargeable batteries are more often than not sold by size, not by letters. You need to know that the battery referred to as an "AA" type is also known as a 14500 (being 14mm diameter by 50mm long – the extra "0" on it tells you which is the longer length) and a "AAA" cell is 10mm diameter x 45mm long, or 10450.

The table shows the various sizes of boards which can be accommodated in the various switched battery boxes.

If you have the knowledge and facilities, a small PCB could be designed and etched to suit the project. Such is the ideal solution but many constructors may not be able to do this.

An alternative is to cut a general-purpose experimenter's PCB to size – such as Jaycar's "Ultra Mini Experimenter's Board" (HP9556) and "IC Experimenters Board" (HP9558)

Battery box	Jaycar code	Altronics code	Number of cells	Circuitry size (mm)	Comment
2 x AAA	PH-9288	S5055	1 x LFP (3.2V)	10 x 45	Suits very small layouts
2 x AA	PH-9280	S5042	1 x LFP (3.2V)	14 x 50	Suits centre rail "fingers"
2 x AA	PH-9280	S5042	1 x ALK (1.5V)	14 x 50	Niche use voltage boosting
3 x AA	n/a	S5041	1 x LFP (3.2V)	30 x 50	Remove 1 box cell rib.
3 x AA	n/a	S5041	2 x LFP (6.4V)	14 x 50	Suits 5V/USB circuits
3 x AA	n/a	S5041	2 x ALK (~3V)	14 x 50	Suits centre rail "fingers"
4 x AA	PH-9282	S5043	1 x LFP (3.2V)	45 x 50	Remove 2 box cell ribs
4 x AA	PH-9282	S5043	2 x LFP (6.4V)	30 x 50	Remove box cell rib
4 x AA	PH-9282	S5043	2 x ALK (~3V)	30 x 50	Matches 3xAA LFP
4 x AA	PH-9282	S5043	3 x LFP (9.6V)	15 x 50	Suits even 9V circuits

These are the most common switched battery boxes – the most expensive sells for less than $3.00. LFP means lithium ion phosphate (LiFePO$_4$) while ALK are your common "primary" (ie, non-rechargeable) alkaline cells.

However, this Paxolin-based board is prone to cracking unless guillotined or first deeply scored on both sides. A box-cutter knife carefully guided along a ruler is satisfactory for this.

The boards offer convenient supply/ground rails under the DIP position, which can be broken or bridged as required. Coarse sandpaper can be used to smooth board edges.

Jaycar's spray-on circuit board lacquer (NA1002) protects, makes soldering easier and enhances board appearance.

Protoboards

As an alternative, some of the larger battery boxes may even fit a portion of a solderless prototyping board.

The technique used to trim a breadboard to 46mm x 30mm can be followed from the pictures. This essentially uses side cutters and a box knife to initially remove the unwanted mount wings, followed by a thin backing slice made to reveal a line of spring contacts. Once these contacts are removed a fine hack saw cut can be made through the empty plastic channel. With care two such trimmed boards can be made from a single 23 x 12 hole mini breadboard. Sand the rough breadboard edges to finish.

The battery

Already, we can hear the question: how is the project going to fit in the box if the space is being taken up by batteries? The answer is simple: use higher voltage lithium secondary cells!

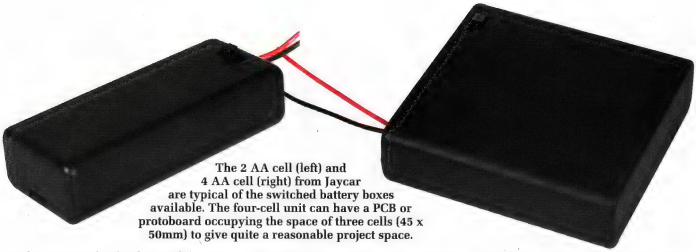
These deliver significantly higher voltages than traditional NiCd, NiMH or alkalines, at currents as good or better – in some cases, much better.

Where three AA or AAA NiCd or NiMH batteries will give you about 3.6V and a pair of alkalines about 3V, a single lithium-ion cell of the same size will give you about 3.7V. There is no "memory effect" that you get with some rechargeable cells.

The higher single Li voltages allow fewer cells for the same supply so you can use the liberated space, (as we mentioned earlier, a "footprint" of 14mm x 50mm per AA cell) to house all manner of simple circuitry on a small PCB or strip board.

However, lithium-ion cells are not perfect: they have a falling supply voltage with use and are very picky about being run too low.

In Silicon Chip June 2013, we looked



The 2 AA cell (left) and 4 AA cell (right) from Jaycar are typical of the switched battery boxes available. The four-cell unit can have a PCB or protoboard occupying the space of three cells (45 x 50mm) to give quite a reasonable project space.

at the merits of safer, longer life and abuse-tolerant lithium ion phosphate (abbreviated LiFePO4 or LFP) types. These are more tolerant than lithium-ion and deliver a very steady 3.2V per cell, almost until their charge is exhausted. This means a single LFP can do the work of two 1.5V alkalines. And it will probably last longer into the bargain.

Naturally, rechargeable cells will eventually need recharging. It's recommended that this be done externally with a dedicated smart charger.

These are available now and they're very well priced – and user friendly. We built one of these into the Porta-PAL-D featured over the last couple of months (it sells for <$15.00).

The one pictured ($AU6.00 from Hong Kong!) charges a "AA" LFP cell in around 90 minutes and can be used from a computer USB port or a dedicated 5V USB supply. Sure, it's a minor inconvenience having to remove the battery and place it in the charger but we think it's a very small price to pay.

Just one word of warning: the rechargeable batteries found online are often (usually?) significantly overrated. In fact, we saw some on ebay recently from a Chinese supplier who actually said in their description "*you may not get 2800mAh from 2800mAh batteries. It is industry thing*"! At least *he* is honest, sort of!

Some posters in local forums who have done accurate measurements report that many of the cheaper rechargeables online are actually half, or even less, of their stated capacity. Even some "brand name" cells are not immune from this as many are in fact counterfeits.

This single AA or AAA charger can handle LiFePO4 or NiMH cells and plugs into a computer USB port or a dedicated 5V supply (either mains or car cigarette lighter). It cost just $6.00 from Hong Kong via ebay.

LED monitoring

While the LFP cells are not as demanding when it comes to low voltage, it's best to avoid running any lithium cell too low.

Just as importantly, when charging multiple-cell batteries you need to use a "balance charger" which individually balances each cell voltage. This will give maximum life/number of charges.

To avoid over-discharging individual cells, we've found using a white, blue or pink LED acts as a useful battery status gauge. Usually, these LEDs are bright at 3.2V but begin to dim below 3V and go out at 2.5V – the recommended level to recharge LFP cells. Remember: "if it's dim then recharge!"

While the LED could be left permanently across the battery, this would obviously act as a continual drain and you'd find the LED goes out far too early and far too often!

Simply use a small tactile switch in series with the LED to act as a supply tester when pushed.

Battery boxes

Switched battery boxes come in 2, 3 or 4 cell versions and sell for only a couple of dollars. An initial decision has to be made on the circuitry size, supply voltage and case ergonomics.

Most switched battery boxes have a lid which closes over the batteries. This may or may not be a problem depending on the height of the circuit board/components but if it is a problem, simply remove the lid.

For basic circuitry a 2 x AA "14500" (or even a 2 x AAA "10450") box may suffice – remember that the circuit board cannot be larger than the battery it replaces. Larger boxes could house even trimmed protoboards.

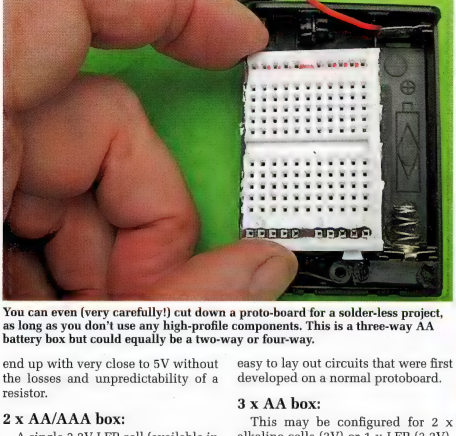
Box alteration

Once the box type is selected it can be internally altered to suit, if needed. However boxes tend to differ in their switch positions, so a careful examination of the cell tabs and switch contacts should first be made. Cell tabs are easily removed with pliers and unwanted ribs snip out with side cutters. Excess cell rib plastic may have to be removed with a "Dremel" or similar, a nibbler or even a file. Fit/refit cell contacts/springs and run the positive supply wire from the switch and the negative from the contact/spring.

Many "5V" circuits will run on 6V or so but there are some which will get upset. Sometimes the specifications say something like "absolute maximum 5.0V +/- 10%", so anything over 5.5V is certainly not recommended.

If you use two 3.2V LFP batteries in series you're obviously going to get around 6.4V.

The easiest way to get around this is to simply connect a pair of suitably rated silicon power diodes (eg, 1N4004 for typical low-power circuits) in series between the battery positive and circuit positive. With around 0.6-0.7V voltage drop across each diode, you'll



You can even (very carefully!) cut down a proto-board for a solder-less project, as long as you don't use any high-profile components. This is a three-way AA battery box but could equally be a two-way or four-way.

end up with very close to 5V without the losses and unpredictability of a resistor.

2 x AA/AAA box:

A single 3.2V LFP cell (available in both AA & AAA form) will directly run all manner of devices, including a PICAXE micro.

LEDs could be mounted in the (enlarged) hole previously used by the flying leads of the battery box. Jaycar's 3.5mm chassis stereo socket (PS-0132) is around 10mm deep and also neatly fits – it could be used for PICAXE programming or even in-situ LFP cell charging.

Jaycar's HP9556 experimenter's board readily makes four AA sized "fingers". The resulting 50mm x 14mm boards offer 20 x 6 solder pads but care will be needed in cutting & trimming to avoid undue weakening of the outer solder pads.

Very tight designs may gain a few millimetres by removing the box mid wall and securing the cell instead with Velcro tape. Although of only modest capacity, a narrower 10mm x 45mm AAA cell could even be used on low-drain circuits.

Jaycar's HP9558 experimenter's board offers more layout flexibility. It features both normal side supply and spare centre rails, along with "3 a side" contacts.

A 20 hole x 10 hole HP9558 "finger" board showed itself as versatile and easy to lay out circuits that were first developed on a normal protoboard.

3 x AA box:

This may be configured for 2 x alkaline cells (3V) or 1 x LFP (3.2V). Although versatile, the alkaline approach is hindered again by the small board housed in the single cell space. A single LFP cell however alllows a trimmed breadboard (11 x 12 holes).

4 x AA box:

This largest switched battery box offers very useful versatility and may even suit as a mini test bench when used with jumper leads.

A two-alkaline supply will allow the same internal rail circuit board approach as used on the single LFP powered 3 x AA box. LFP cells are more expensive than AA so their use may be unjustified for some simple projects.

However, when gutted to just a single LFP, it'll even house a trimmed (20 x 12 holes) breadboard, complete with full supply rails and even top and side hole ID lettering.

Head room on a breadboard is a rather tight 5mm, but this doubles to a tolerable 10mm when housing a soldered board.

Enhanced board real estate now allows all manner of circuits to be designed and built and finally neatly housed in a battery box. Sufficient internal cavities remain to allow diverse indicator LEDs, I/O connections and sensors to be mounted as well.

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Finish:

Neat external labels can affixed and covered with clear tape for protection. It's particularly important to also indicate the cell type the circuit is intended for, else sub-standard performance or over driving may result. Dummy cells can of course be used – a single LFP in series with a dummy cell gives 3.2V, which almost matches the voltage of two alkaline cells.

The prospect of connecting several LFPs in series may tempt, but cell matching (relating to differing cell charge, discharge and aging characteristics) may become an issue for long term projects.

Simple setups can readily however be organized, and a couple in series (2 x 3.2V = 6.4V) will be good for 5V USB style delivery (after regulation), three for 9V (3x 3.2V = 9.6V) with four in series (4 x 3.2V = 12.8V) even capable of a healthy and lightweight 12V supply.

Just don't try and jump start your car with them! SC

Resources: Conveniently located at www.picaxe.orcon.net.nz/bbox.htm

Yet another dongle – this time it's a spectrum analyser!

Jim Rowe spotted this USB Mini Spectrum Analyser dongle on eBay and was so intrigued he purchased one. Despite its tiny size and low cost, it offers impressive performance over the frequency range from 1MHz right up to 5.35GHz – with a few limitations but not enough to stop it being very handy for many portable applications.

By JIM ROWE

LIKE MOST TEST instruments, spectrum analysers have shrunk in cost and size in the last few years, thanks to accelerating solid-state technology. But when someone talks about a portable spectrum analyser, most of us think of an instrument maybe just a little larger than a portable DSO.

A recent example of these advancements is the Gratten GA4063 analyser I reviewed in the November 2013 issue of SILICON CHIP (page 84), which measures 400 x 210 x 136mm and weighs a modest 7kg. That's much smaller and lighter than the spectrum analysers of only 15 years ago and its price tag of below $8000 is also considerably lower.

There's also the RF Explorer reviewd by stan Swan in the May 2013 issue of SILICON CHIP. It covered the range from 240-960MHz.

But the technology is still galloping on, at an ever increasing rate. Early in 2013, a small Canadian firm called Triarchy Technologies Corp released the first of a series of Mini Spectrum Analysers housed in a USB dongle measuring a mere 87 x 23 x 15mm – including a USB type-A plug at the output end and an SMA female connector at the input end. It weighs less than 20 grams.

Despite this tiny size, the TSA5G35 analyser covers the frequency range from 1MHz right up to 5.35GHz and offers some impressive features, including sourcing all of its power from the PC, via the USB cable; no separate power supply or battery pack is required. That's what we call portable!

And buying it via eBay, the cost of the TSA5G35 is much lower than you'd expect: US$599.00 plus US$30.00 for handling and international shipping, which equates to about A$750.00 at the current exchange rate. That's about 1/10th the cost of the next-cheapest fully self-contained spectrum analyser covering the same frequency range.

By the way, the TSA5G35 comes in a small black cardboard case, with protective foam around it. There's a matching 30dB fixed RF attenuator alongside it, with SMA connectors at both ends so it can be easily screwed onto the input of the TSA5G35 to extend its signal level range. There's also a 1m long USB extension cable (type-A plug to type-A socket) so you don't need to have the TSA5G35 plugged directly into the PC's USB port.

Main features

Here's a listing of the main technical features that the unit offers:

(1) Input levels up to +20dBm (100mW) with the basic TSA5G35, rising to +30dBm (1W) with the add-on fixed RF attenuator.

(2) Built-in digitally-controlled input attenuator with seven ranges, covering from 0dB to -60dB in 10dB steps. This attenuator is also used to set the analyser's reference level.

(3) A noise floor which hovers around -110dBm (710nV at 50Ω) for most of the frequency range, creeping up to -105dBm at around 1.6GHz and then to -100dBm (2.2μV) at 4.5GHz and above. The rated noise floor figure is -115dBm, measured at 1.0GHz with 5MHz span and the reference level set to -60dBm (I checked this with the unit I purchased and obtained an average reading of very close to -119dBm).

(4) A choice of eight software selectable ranges when it comes to frequency span: 1-2-5-10-20-50-100-500MHz and 1000MHz, although there is a

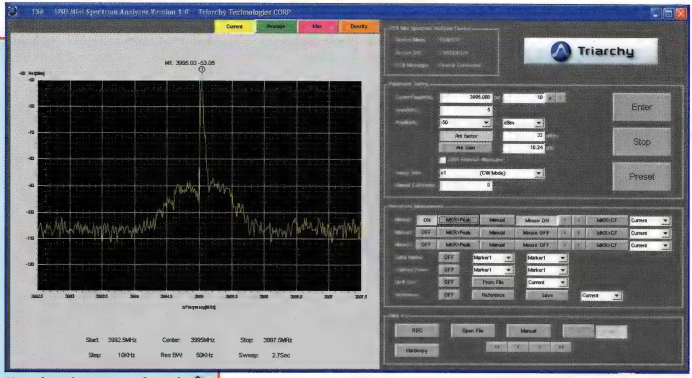

Fig.1: the software control panel has a wide range of settings and allows you to set markers to read the frequency and level at various points in the spectrum. The four coloured tabs at top let you choose the Current, Average, Maximum & Density plot modes, or combinations of these.

proviso in that the two widest spans can't be used where they extend over the 850MHz point in either direction. That's because the TSG5G35 actually covers its overall frequency span in two ranges: 1MHz - 850MHz and 850MHz - 5.35GHz.

(5) Four different resolution bandwidths (RBW): 50kHz, 100kHz, 200kHz and 500kHz. These are automatically selected by the Triarchy software to give the clearest display for each span range.

(6) Minimum sweep time of two seconds ('1x'), which can be extended by factors of 1.5x, 2x, 4x, 8x, 16x or 32x.

(7) Here's a few more hardware-related specs: minimum frequency step for 1MHz span is 2kHz; frequency stability better than ±5ppm with software calibration (not explained as yet); reference level accuracy quoted as <3dB between 100MHz and 5.35GHz at the 'top level' of the internal step attenuator; reference level flatness is quoted as <2dB within 100MHz span, also at the 'top level', and display range linearity is quoted as <4dB at 1GHz.

(8) The Triarchy software has the capability of calculating and displaying not just the 'current' scanning plot, but also the 'average', 'maximum' and 'density' plots as well if you wish. Any of these four plots can be enabled or disabled simply by clicking on their respective 'tabs' at the upper right of the display. The different plots are colour coded to allow them to be distinguished from each other.

(9) Other features of the software include the ability to set a number of measurement markers on the plots/waveforms; to set the software to make allowance for the external 30dB attenuator, any input cable loss or antenna gain; to allow the user to select any of five different options for displaying the reference level and amplitude plot ordinates – dBm (the default), dBµV, dBmV, dBµV/m or dBmV/m^2; to allow the user to save not only 'snapshots' of the current plots for printing out, but also to 'record' the scan data to disc, for processing by other software.

A User Manual for the TSA5G35 and its software can be downloaded as a PDF file from www.triarchytech.com However, note that the manual is currently still in draft form and as yet a bit sketchy in places. On the other hand, Triarchy already has a series of Application Notes available, all PDF files which can be downloaded from their website. These cover the testing of signals from Bluetooth, DECT, mobile phones, SRD and RFIDs, WiFi routers and Zigbee.

Trying it out

So far, I've tried out the TSA5G35 on a desktop PC running Windows XP/SP3 and a laptop running the 64-bit version of Windows 7. In both cases, the TSA5G35 and its software worked fine, the only difference being that things do slow down a bit on the Windows XP machine when you select the 'density' plot. However, Triarchy

The Triarchy USB Mini Spectrum Analyser fits easily in the palm of the hand. Despite it's tiny size, it covers the frequency range from 1MHz to 5.35GHz.

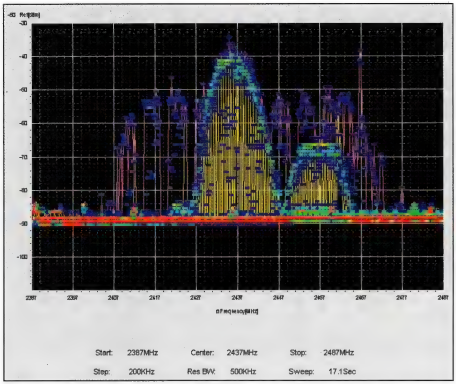

Fig.2: this spectrum plot shows the WiFi signals coming from the author's network router. The yellow trace shows the most recent 'current' plot, while the magenta trace shows the maxima and the somewhat splodgy blue and cyan trace shows the density plot.

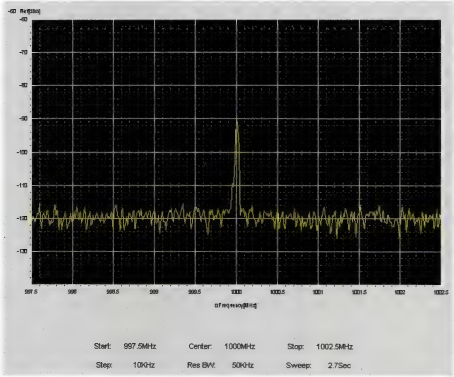

Fig.3: the 'current' plot of a 1GHz signal from a Gratten GA1484B generator, with an output level of -90dBm (7.1µV) and using a direct connection. The signal peak is very close to -91dBm (possibly due to small losses in the connectors).

warns that this option does involve a lot of processor 'crunch power' and so really needs a fast and powerful machine running 64-bit Windows 7.

Overall, the device and its software are quite easy to drive in terms of making the majority of common spectrum analyser measurements. I also found that it met or exceeded its main performance specifications, although the user manual doesn't explain (as yet) how to calibrate it in terms of frequency or amplitude level.

While checking the TSA5G35's noise floor over the full frequency range, I did find small spurious signal peaks at 48MHz and 96MHz. These seem likely to be from an oscillator inside the dongle but as they were both quite small (-99dBm and -101dBm), they don't seem likely to cause any real problems in most applications.

I also tried using the TSA5G35 to look at the WiFi signals coming from my network router, using a small 'whip' antenna from an old router connected to the input of the TSA5G35 as a near-field 'sniffer'. The plots I obtained with this antenna (and the TSA5G35) spaced about 1.5m from the two antennas of the router are shown in Fig.2.

To make things clearer, the yellow trace shows the most recent 'current' plot, while the magenta trace shows the maxima and the somewhat splodgy blue and cyan trace shows the density plot.

As you can see, they show that most of the signals are centred on 2437MHz, which seems to be 'channel 6' in the WiFi band, with a smaller group of signals centred on 2457MHz (channel 10) and even fewer signals outside these two main groupings.

Other tests I tried involved using the TSA5G35 to check the output of the Gratten GA1484B signal generator I reviewed in the November 2013 issue, with the generator set for different frequencies and output levels, and with either a direct connection between the two or via a 1m long RG-213 cable. In each case, I also had to use an N-type to SMA adaptor and, in some cases, an SMA gender changer as well.

You can see the results of a couple of these tests in Fig.3 and Fig.4. Fig.3 shows the 'current' plot of the generator signal at 1GHz, with an output level of -90dBm (7.1µV) and with a 'direct' connection. Although I didn't set a marker for the signal peak, it clearly shows a level of very close to -91dBm. I presume the 1dB difference is due mainly to losses in the two connector series adaptors but there may also be a small error in terms of the TSA5G35's level calibration.

Fig.4 shows the result of the same kind of test with the generator output

set to 3.9950GHz and an output level of -50dBm. As you can see, the peak level in this case is shown as -50.55dBm, suggesting a smaller loss in the series adaptors. On the other hand, the peak frequency is shown as 3995.04MHz, which suggests a small error in TSA-5G35's frequency calibration. While not all that great, hopefully this can be reduced when I find out how to perform the 'software calibration' . . .

Any complaints?

Not really – just a few minor niggles, which can hopefully be sorted out by Triarchy Technology when they produce the final version of the TSA5G35 User Manual and also gradually improve the control software.

For example, you can't at present program a scan by specifying the start and stop frequencies; you can only do it by setting the centre frequency and the span. This can often require either a little mental arithmetic or a pocket calculator. It would be nice to be able to set a scan by specifying the start and stop frequencies, as an alternative.

It also be good to have the ability to change the resolution bandwidth (RBW) manually and perhaps be able to achieve spans of less than 1MHz, eg, 100kHz.

To summarise, the TSA5G35 USB Mini Spectrum Analyser seems to be a very capable little performer, particularly when you consider its remarkably attractive price. While its performance is clearly not up to the level provided by much more expensive self-contained analysers, my impression is that it provides most of the capabilities needed for general purpose spectrum analysis. This would include checking cordless phones and wireless video links, mobile phones and 2-way radio gear, Bluetooth and WiFi gear, and so on.

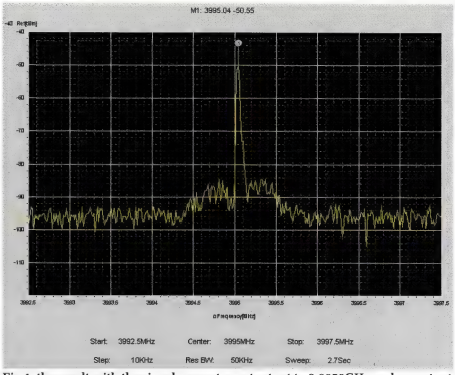

Fig.4: the result with the signal generator output set to 3.9950GHz and an output level of -50dBm. The peak level is now -50.55dBm, indicating a much smaller loss in the series connectors. The peak frequency indicated is 3995.04MHz, due probably to a small error in TSA5G35's frequency calibration.

It should also be suitable for near-field EMC testing out in the field.

By the way, you don't have to search around on eBay to find the Triarchy TSA5G35. All you need do is go to their own website at **www.triarchy-tech.com**, click on the [Products] button, select the TSA5G35 from the list of products and then click on the 'To order from eBay click here' link.

If you do go to their website, you'll find that they are now manufacturing three other USB dongle-based spectrum analysers as well. One, designated the TSA4G1, covers up to just 4.1GHz and is a little cheaper than the TSA5G35. Another, designated the TSA12G5, covers the frequency range from 4.9-13.5GHz and is more expensive. **SC**

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Salvage It!

By BRUCE PIERSON

Harvesting a Dead PC Motherboard for Parts

Last month we looked at the goodies we could salvage from a dead PC supply. But what about the motherboard? There's a lot of useful parts on there, too . . . but getting them off sometimes proves difficult!

It's estimated that the average life of a desktop computer these days is little more than two years. After this time, its performance can be agonisingly slow compared to "the latest and greatest" to the point where, if it is being used in a business environment, it is likely to be actually costing money – merely in "wait" time. Even worse, it is probably not able to keep up with the latest software.

Or consider the other scenario: your computer has "died" – the power supply still works but there is an obvious motherboard failure.

In either case, your choice is to either replace the motherboard (along with memory, probably a new hard drive, etc) or simply replace the whole thing.

Financially, replacing the motherboard is often the best solution (though not always!), so let's assume you've gone that route and in the process, ended up with an old one. You could just discard it, or you could wreck it for parts and get a bunch of useful components from it for the junk box before tossing the skeleton.

What parts can you salvage from a dead motherboard? Well, it depends on the type of motherboard you have to start with. We can categorise motherboards into four broad categories. (We'll forget about *really* old types!)

(1) Older motherboards that use SD RAM. These boards tend to have more, smaller sized and smaller value electrolytic capacitors of a higher voltage, typically 330µF 25V, no USB headers and not much in the way of heatsinks (if any).

(2) Not-quite-as-old motherboards that use DDR RAM. These boards usually have several physically larger electrolytic capacitors of higher capacity and lower voltage, typically 2200µF 6.3V and a number of smaller capacitors, USB headers and inductors.

3) Newer boards that use DDR-2 RAM. These are similar to the DDR boards.

4) Newest boards using DDR-3 RAM. These usually have solid capacitors of smaller physical size and sometimes a few of the older electrolytic capacitors, more heatsinks, more choks and more headers for USB, fans and other connectors.

The photo above shows a typical older motherboard that takes SD RAM. This was the only dead motherboard available for "harvesting" at the time of writing, so it has been sacrificed for this article.

Motherboards are multi-layer fibreglass in construction, with layers of track-work buried inside. With plated-through holes, de-soldering components can be quite difficult, due to the heat transfer through the multiple layers of track-work throughout the board.

So, how do we remove the components? Well, components with only two leads, such as capacitors, can generally be removed with a 40W soldering iron, by heating each lead in turn and bending the component gently to the side after the solder has melted.

This procedure is repeated several times, until the component is free. However, this method won't work for multi-lead components, such as ICs or header pins, etc.

A blowtorch to the ~~belly~~ motherboard

The best method I have found for releasing such components is to use a small gas blowtorch set on the lowest

level possible, with the flame angled across the board, in order to melt the solder and minimise heat transfer to the components.

If you are using this method to salvage parts, **you need to take a lot of care** and proceed in a manner so as not to endanger life or property. Firstly, it should be noted that using this method produces a lot of smoke and the board will often catch fire during the procedure. However, this presents minimal risk to the salvager, ***if the proper precautions are taken.***

It goes without saying that this procedure must be carried out outdoors in a well-ventilated area, away from flammable material. Make sure you have a bucket of cold water on hand in case of burns (or fire!) and wear safety equipment: insulating gloves, protective glasses and so on.

Quite often, small SMD components may "explode" off the board and be projected in any direction and the last thing you need is an extremely hot component landing in your eye. Overheated "normal" components can also explode.

It sometimes happens that a ball of solder will drop from the board, so make sure you don't get in the way, nor have any skin exposed. Remember, this solder will be very hot – hotter than you are used to with an iron – and can make quite a decent burn hole in your skin (and/or clothes).

Hot air gun alternative

An alternative to the blow torch (and an arguably safer) method) is to use a hot air gun, (a real one, not a hair drier!) set on high heat.

It is a slower process and can actually heat the components even more than a flame (due to the fact that the heat must be applied for longer). Hot air guns are still quite capable of heating a PCB to the point where they catch fire and can, of course, also cause you damage if you get in the blast!

Another possibility is an SMD re-work hot air station but not many readers are likely to have one of these!

Removing connectors

When removing items such as USB headers and IDE connectors, it's a good idea to plug an old cable into the header. This helps to minimise the heat transfer to the plastic base and keeps the pins straight and aligned, as well as providing a convenient "handle" to remove the header with.

After the header has cooled, it can be removed from the cable and stored for future use. USB headers are handy when making a power supply and fan connectors can be added to a project to enable the use of a computer fan in the project.

Depending on what motherboard you start with, you will most likely end up with a different assortment of components to those shown above. The above selection is somewhat minimalistic, due to the age of the board that was wrecked. A better selection of components will be obtained from newer motherboards.

However, we salvaged the following components from this exercise, so it was still worthwhile. The alternative would have been to bin the dead motherboard and all those components would have gone to waste:

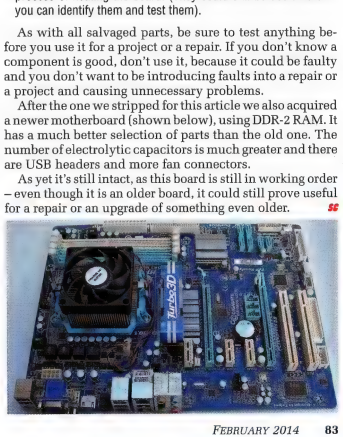
25 Electrolytic capacitors, mostly 330µF 25V (a better selection is on newer boards),
1 3A diode
2 1A diodes (which fell out by themselves)

1 ceramic capacitor
2 large inductors
1 small inductor
1 header strip
1 battery holder
1 battery (probably dead if it's an old motherboard)
5 3-pin headers and 5 jumpers to suit
1 20-pin power connector (not overly useful!)
3 transistors of unknown type
1 32-pin IC socket (great if you have any 32-pin ICs!)
1 PROM (useless unless you have an identical motherboard)
1 floppy header (what is a floppy?)
2 IDE headers – these can be used with cables to connect PCBs
1 8-way DIP switch (not usually found on newer boards)
1 dual USB port
1 crystal (unlabelled but probably around 8MHz)
2 serial ports and 1 parallel port – probably not much use for anything?
1 fan connector which can be used in a project to plug in a fan
Various screws and nuts
A bunch of SMD components which fell off by themselves in the process of heating the board. (They could still be useful later if you can identify them and test them).

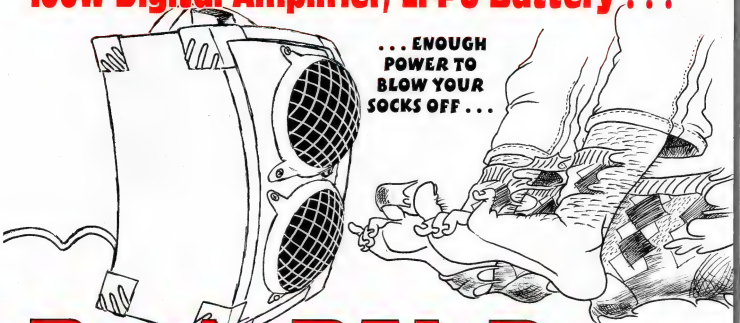
As with all salvaged parts, be sure to test anything before you use it for a project or a repair. If you don't know a component is good, don't use it, because it could be faulty and you don't want to be introducing faults into a repair or a project and causing unnecessary problems.

After the one we stripped for this article we also acquired a newer motherboard (shown below), using DDR-2 RAM. It has a much better selection of parts than the old one. The number of electrolytic capacitors is much greater and there are USB headers and more fan connectors.

As yet it's still intact, as this board is still in working order – even though it is an older board, it could still prove useful for a repair or an upgrade of something even older. SC



100W Digital Amplifier, Li-Po Battery . . .



PortaPAL-D

by John Clarke

Part III - Building the Box

We've finished the electronics module – now it's time to put together the cabinet which houses that module along with the two speakers to make LOTS of beautiful music.

The PortaPAL-D box is made from 16mm MDF (medium density fibreboard) and rectangular DAR (dressed all round) pine. Its overall dimensions are 332W x 600H x 318D mm, chosen to suit the standard MDF sheet sizes that are available.

The box is covered in speaker carpet with corner protectors, a handle and a top hat for use with a speaker stand. The two speakers are each protected with a metal grille. Fig.15 show the speaker box construction.

The speakers are within their own sealed box, while an "alcove" is made in the top rear of the box to house the PortaPAL-D chassis.

The inside volume for the speakers is around 33 litres, however, by packing the space with fibreglass insulation or fibrous wadding, the effective volume can be increased by as much as 40%. This apparent increase is due to a reduction in the speed of sound in the box due to the packing.

Fig.16 shows the typical bass end response with an unfilled box. This shows a 2.7dB peak at about 120Hz. With filling, this peak can be reduced to below 2dB so that the bass response becomes more damped. A further benefit of the wadding is in the reduction of internal reflections from the cabinet walls.

Incidentally, we used WinISD 0.44 box modelling software by Juha Hartikainen. (www.linearteam.dk). Thiele/Small parameters for the specified Altronics C2005 speakers are: V_{AS}= 27 litres, Q_{ES}= 0.962, Q_{MS}= 4.172, Q_{TS}= 0.782 and F_o= 58.428Hz.

The basic box shell comprising the top, bottom and two sides is made using two 600 x 300mm and two 300 x 300mm sheets of MDF. The front speaker baffle is 300 x 568mm and fits into these surrounds, as does the 300 x 365mm lower rear piece.

Two more pieces form the "alcove", one 300 x 157mm and one 300 x 201mm.

These can be cut to size with a machine or hand saw and are assembled using PVA glue and nails or screws.

If they offer a cutting service, you might find it better to have the store where you purchase the MDF to cut the pieces for you, as this will inevitably result in a squarer, more even finish.

Internal cleats using 12 x 12mm DAR pine can be placed inside the edges of the box. You will need to keep the edges free of cleats where the box is

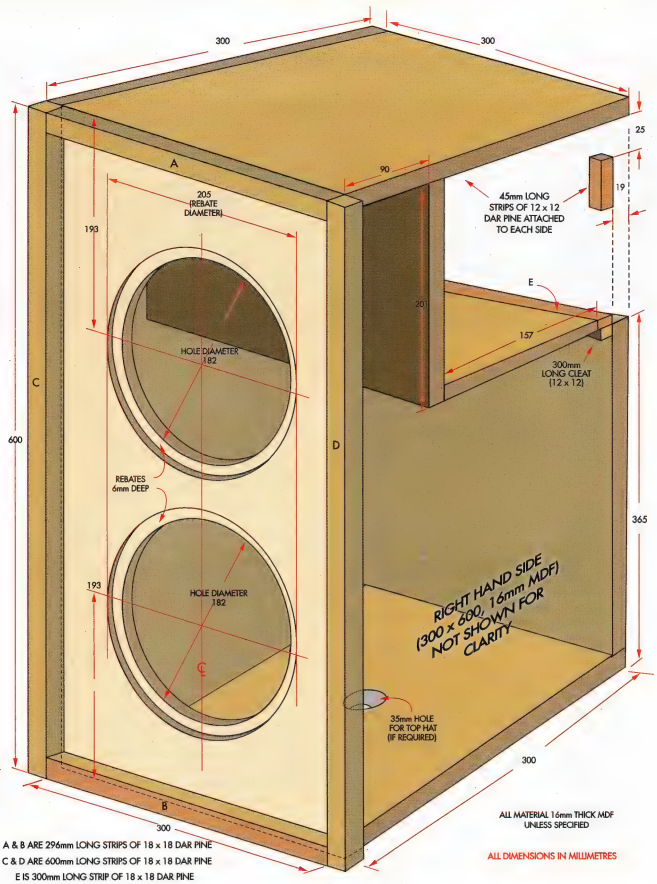


Fig. 15: here's a diagram of the complete PortaPAL-D Speaker Cabinet, albeit without one side (that's so you can see how the electronics module housing is made). We've deliberately selected the sizes so that it can be made from standard sheets of MDF (medium density fibreboard). If you have the option, we'd suggest you get the MDF supplier to cut the panels to size for you – that way, you get nice, straight, clean cuts which make for a nice, airtight box.

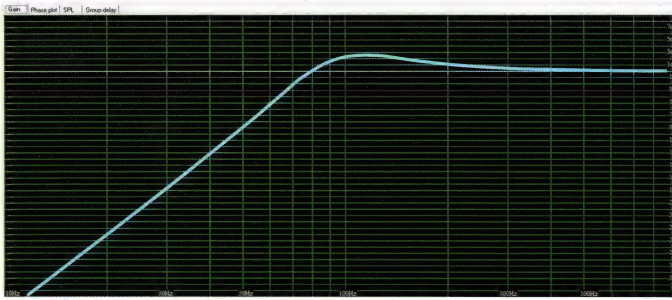


Fig.16 shows the typical bass end response with an unfilled 33 litre box. This shows a 2.7dB peak at about 120Hz. By packing the space with fibreglass insulation or bonded acetate (BAF) wadding, the effective volume can be increased by as much as 40%. This apparent increase is due to a reduction in the speed of sound in the box due to the packing. With this filling, the 2.7dB peak can be reduced to below 2dB so that the bass response becomes more damped. A further benefit of the wadding is a reduction of internal reflections from the cabinet walls.

made to house the PortaPAL-D chassis.

Once the glue has dried, mark out the 205mm and 182mm rebate diameters for the two loudspeakers to sit into on the front panel. Use a router to cut this rebate to a depth of 6mm. Now fully cut out the 182mm diameter holes with the router.

If you intend to install the speaker stand top hat, the hole for this (located centrally in the base of the box) can be cut now using a 35mm diameter hole saw.

Similarly, the holes for the handle that mounts on the top can be drilled.

While we only used (and specified in the parts list) a single handle on top of the box, the finished PortaPAL-D is quite heavy (17.5kg) so can be quite tiring if carried any distance.

You might prefer to place a handle, say, one third the way down each side of the box, for easier carrying by two people. Another refinement which you might consider is mounting four small furniture castors or wheels, one in each corner, to make the PortaPAL-D easier to move. That's up to you.

For the handle, we used two of the screws and captured nuts that are provided with the speaker grille clamps to mount the handle.

This leaves just three screws and nuts for each speaker grille mounting using the clamps. That is sufficient for these grilles when spaced out 120° as shown in the photographs. Position the grilles over the speaker holes and mark out the hole positions for each clamp. Drill and attach each T-nut for the grilles and handle(s) by tightening up the screw to pull the nut into the MDF. Once these nuts are secured, remove the screws.

The front surround is 18 x 18mm DAR pine and can be cut and glued to the front of the box. The purpose of this is to recess the speakers (even though protected by grilles) from the inevitable bumps and scrapes of a portable system.

When the glue is dry, round off the eight corners of the box using a rasp or file to form the same curvature as the corner protectors.

Electronics chassis housing

The internal MDF boxed-in section for the PortaPAL-D chassis can now be made. Cut the sheets and DAR pine to size and glue these in place. Note that there is not much clearance between the back of the top speaker magnet and the internal box.

There needs to be a gap between the speaker magnet and box otherwise resonances are likely, so check that there is at least a 1mm gap between the speaker and the MDF sheet before finally gluing in place.

Note that when installing the speakers, there will be a nominal 1mm thickness of sealant around the rebate to seal the speaker from air gaps. This should be considered when checking the clearance gap.

Two 12 x 12 x 45mm DAR pine pieces are set 19mm in from the rear and 25mm down as shown. These are for supporting the top of the PortaPAL-D chassis. The lower 18 x 19 x 300mm DAR pine piece supports the lower PortaPAL-D chassis. When all is complete, ensure that all the joints are airtight by running a bead of PVA glue around all internal joints.

At this stage, test the PortaPAL-D chassis for fit into the sealed cavity. Hopefully you will not need to make any changes to the box so that the chassis will fit. The advantage of having the two handles on the front panel will be realised when trying to remove the chassis.

Drill pilot holes for the 4g x 16mm panhead screws that secure the panel to the cabinet.

You may wish to paint the inside of the PortaPAL-D chassis section of the box black so that any exposed MDF or pine that is not covered by carpet is not obvious.

Carpet

The speaker carpet is attached to the box using contact adhesive. The carpet can be cut into just three separate pieces. First is the surround piece that wraps around the entire sides of the box, second is the front baffle (296 x 564mm) and third is the rear panel at

These shots, front and rear, show the completed PortaPAL-D box, with carpet, handle and corner protectors fitted, immediately before installation of the electronics chassis (left) and the two speakers (right). The speaker wire is already in place, emerging from the hole drilled in the left photo for connection to the PortaPAL-D chassis.

300 x 401mm.

You will need a long straight edge to cut the carpet along and a steel ruler to make the measurements. A 'Stanley' knife (or a larger hobby knife) can be used to cut the carpet against a cutting mat.

Cut the front baffle carpet first. Lay it against the baffle as a sanity check and if it appears correct, remove and apply a smear of contact adhesive to the front baffle. Fix the carpet in place, smoothing out the carpet against the baffle (a small roller is ideal).

Now for the side carpet piece: this needs to be wide enough to also wrap around the front 18mm DAR pine, folding at two 90° bends to reach the front baffle. It also has to fold around at the back edge and reach 19mm inside the box where the PortaPAL-D chassis fits.

That means the carpet needs to be 389mm wide and 1864mm long. The amount of overhang at the front while wrapping the length around the box sides will need to be 36mm and the amount at the rear at 35mm.

Again, loosely wrap the carpet around the box to make sure it is going to fit properly and if all is well, remove and apply contact adhesive to the bottom of the box. Glue the beginning end of the carpet to this with the end of the carpet placed along the box edge.

Then apply the adhesive to the next side and wrap the carpet around that side taking care to maintain the correct overhang front and back. Continue gluing the top and then the other side, affixing the carpet as you go. Rub your roller (or hand) over the carpet to smooth it out and to maintain contact with the box till the adhesive is dry.

It's probably best to leave the box until the adhesive is dry to prevent pulling away. Once you're satisfied that the carpet won't move, trim each corner with a sharp knife or scissors to allow the carpet to wrap around the front and back of the box. Test how each piece will wrap around the box before cutting off too much carpet and before gluing in place. Any removal of too much carpet can be covered over with a suitable shaped extra carpet piece carefully glued in to fill the hole. The fold-over at the rear needs to go down the sides into the recessed PortaPAL-D cavity by 19mm.

The rear piece for the lower portion of the box can be cut to 300mm wide x 401mm and this needs to start by wrapping into the bottom edge of the PortaPAL-D cavity by 19mm and then glued down the 18mm DAR pine and then the back of the 300 x 365mm panel. The side wrap carpet can be cut to just 16mm for the lower part of the box allowing the 300mm width to fit.

Fittings

When the adhesive is dry, cut out the carpet about 3mm smaller than the 205mm perimeter of the rebate

Here's what your finished PortaPAL-D should look like, from the front (speaker side) shown at left and the rear (control side) shown at right. With a maximum power of 100W and a continuous 50W, you're not going to lack for volume – and the comprehensive range of mixer controls means it will handle just about any application. Add the Li-Po battery and inbuilt charger, it's a real winner! With 20/20 hindsight, we would have replaced the single carry handle with a pair of more robust handles on the side – it does get a little heavy even after carrying it a short distance! (That does mean a two-person carry, though). And we'd also think about putting some small castors or wheels on the bottom to make it easier to cart around.

hole for each speaker hole. Also find the T-nuts for the speaker grill clamps and handle and poke a hole through the carpet at each nut. A size 2 Philips screwdriver can do this.

If using the top hat, carefully cut out a hole in the carpet, same diameter as the top hat stem, and insert that into the hole. By pressing the top hat down in place, and using the top hat flange as a cutting template, carefully cut the carpet around the perimeter of the top hat flange. Remove the circle of carpet and reinsert the top hat. Pilot-drill the mounting holes for this and screw in the screws. Attach the handle to the top of the box.

The corner protectors can now be attached using 6g x 16mm bronze-coloured countersunk wood screws.

Installing speakers

The speakers are next and will require wiring up as they are installed.

The specified speakers (Altronics C-2005) are 200mm, 8Ω coaxial models and connected in parallel, to present a 4Ω load to the amplifier.

These speakers feature push-button terminals so no soldering is needed. However, they must be connected in phase; ie, plus to plus and minus to minus. The easiest way to do this is to cut the 1m length of 7.5A figure-8 cable in half, bare all ends to 1cm and tightly twist together one end of each (make sure the stripes or polarity markers are twisted together).

Drill a small hole suitable for one of the figure-8 wires to pass through the rear of the PortaPAL-D box cavity, about 25mm down from the inside top.

Hang the twisted-together pair of cables out of the top speaker hole and the other end of one cable out of the bottom speaker hole.

From inside the case, push the other single figure-8 through the hole in the box cavity.

We'll mount the lower speaker first. Connect the figure-8 cable to the push terminals, with the stripe or marker on the figure-8 going to the red (+) terminal.

To give an air-tight seal between speaker and box, we're using Blu-Tack putty. Roll a long length so that you end up with a cylinder about 2mm in diameter and mould this all the way around the rebated section in the box for the lower speaker.

Repeat until you have a solid run of Blu-Tack all the way around (ie, no gaps).

Pack about 90% of the wadding in the volume behind the lower speaker hole and slide the speaker into the lower hole under the carpet lip that surrounds the rebated outer hole diameter. Press the speaker into the hole to compress the Blu-Tack. Now carefully (!) drill pilot holes into the rebate at the four mounting holes on the speaker and secure the speaker in place with 8g x 12mm panhead screws.

Now the upper speaker. It has the twisted-together pairs of figure-8 connecting it but there is plenty of room in the push terminals. Once again, ensure the striped wires go to the red or + terminal.

Insert the remaining wadding around the outside of the speaker hole (but not directly behind where the speaker goes) and install the speaker as before using Blu-Tack and screws. Now the grilles can be positioned over the speakers and held in place with the clamps.

Where the speaker wire comes through from the speakers to the PortaPAL-D chassis, ensure that you have plenty of cable to work with and then seal the hole with Blu-Tack. This wire connects to the 'to speakers' terminals on the speaker protector.

A 2-way 15A terminal strip is an option to allow the 'to speakers' output to be extended for an easier connection to the speaker wire.

Insert the PortaPAL-D chassis into the box cavity and secure using 4g x 16mm panhead screws.

Construction of the PortaPAL-D is now finished. Turn on and check that it works with the inbuilt battery, then connect power and check that it charges. SC

Replace Mercury High-Bay Lights with LEDs and $ave $$$

by Ross Tester

Back in February last year, we told you how we'd not only brightened up a dingy corridor by replacing halogen downlights with purpose-made LED fittings, we expected to significantly reduce our power consumption in the process. Now we're at it again – this time replacing power-hungry mercury discharge warehouse lights.

The LEDs we used in that feature came from Tenrod – and recently, another press release arrived from them telling us about their industrial high-bay LED fittings.

Having quite a few high-bays in our building and knowing their shortcomings, we were immediately interested: could these achieve the same sort of savings and utility as we managed last time?

High-bay?

For those who may have spent their lives cloistered in an office or outside in the sunshine, we'd better explain the term "high-bay".

They're the light fittings of choice in warehouses, etc and typically come fitted with a 400W mercury discharge lamp.

We've shown a photo above of one of the high-bays in our warehouse (on left), alongside a new LED high-bay, to demonstrate what we are talking about.

The most obvious difference is the size and shape – the mercury high-bay is significantly higher but has a more parabolic-shaped reflector. The LED high-bay is squatter and has a wide, cone-shaped reflector.

Incidentally, the mch higher apparent brightness of the mercury high-bay in this photograph does not tell the full story. Partly this is due to the fact that the camera sees much more light from the reflector because the lamp radiates over much wider angles than the LED array. In fact if you look directly at both lights (ie, especially on axis), the LED array looks dramatically brighter – nearly blinding, in fact!

As their name suggests, high-bays are designed to be mounted high up – usually near the roof (most industrial areas don't have ceilings!) more than five metres off the ground.

They're large (typical high-bay fittings have a 300-400mm diameter reflector and are perhaps 500mm high); they're heavy (due to the ballast circuitry almost invariably fitted to the top of the reflector); they're quite expensive (typically between $250 and $300 each) and, typically, they take quite some time to come up to full brightness from turn-on (perhaps 10 minutes or more).

However, when they do come fully on, they are very bright and with the right reflector, produce a good spread of light.

Waiting, waiting . . .

But perhaps the worst feature of the mercury high-bay is that if power is interrupted, even for a moment, they extinguish but take even longer to cool down and then restart. So a warehouse or production area can be plunged into blackness for quite a number of minutes before you have any light;

	Mercury High Bay	AdvanceQuez LED High Bay	AdvanceQuez LED Flood
Power			
Rated	400W	120W	130W
Measured	404W	118W	133W
Brightness			
Dedicated light meter (Digitech QM1587)	550 lux	3060 lux	13620 lux
Multimeter with lux measurement (Digitech QM1580)	760 lux	4330 lux	19980 lux
Photographic light meter on "EV/ ambient" setting (Minolta IV-F)	7.7 EV	9.9 EV	12.1 EV
Lumen output (manufacturer's data)	22000 typ.	>9000	10800

"Real world" measurements comparing the three lamp types. These were all taken on-axis at 4 metres, after 15 minutes to ensure full warm-up. The apparent discrepancy between the lumen output of the mercury high-bay and the LED models is due to the more diffuse pattern of the mercury. In fact, on the floor below, the LED light pattern is significantly brighter to both the eye and to instruments. EV, or exposure value, is more a photographic measurement but being related to aperture and *f*-stops, gives a relative measure between the light sources. Both LED fixtures were "cool white" with a colour temperature of 5600-6500K.

not good when there is machinery or moving equipment!

We just mentioned a moment ago that they are normally fitted with a 400W mercury lamp. Thankfully, these have quite a long life because (a) the bulbs are expensive and (b) getting up to change lamps can be quite a chore with a scissor-lift typically being required.

But it's not only the lamp that's draining power: the ballast gets rather warm and you are paying for that heating.

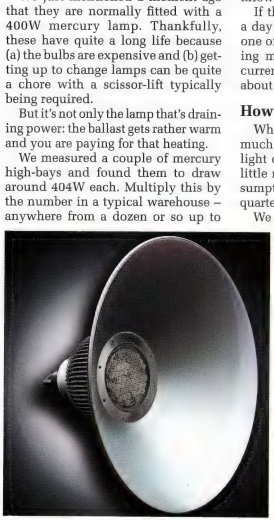
We measured a couple of mercury high-bays and found them to draw around 404W each. Multiply this by the number in a typical warehouse – anywhere from a dozen or so up to perhaps 50+ in a big installation and you can see that you are up for many kilowatts of (now very costly) power.

If those lights are on for 14 hours a day (by no means uncommon) just one of those high-bays could be costing more than $800 per annum (at current business electricity rates of about 40c/kWh).

How to reduce that power?

What if you could get at least as much – and probably much more – light output from your high-bay at a little more than a quarter of the consumption? Obviously, that means a quarter of the cost of electricity as well.

We are talking LED replacements for your existing lamps. Once again, these were supplied by Tenrod – and they had two different styles available for us to look at.



Definitely not the reflector shape you're used to with the older mercury high-bays – and at 510mm diameter, these LED high-bays are much wider. But you can enjoy significantly more light output AND save a lot of power into the bargain! One other big advantage the LED high-bay has over its mercury cousin is significantly lower UV output – normally not a factor but certainly can be in some installations, such as indoor sporting venues.

LED high-bay

One is a straight swap for the ubiquitous mercury discharge high-bay. The fitting looks somewhat like a traditional high-bay, albeit with a simple conical reflector rather but instead of the mercury lamp (and ballast) it has a 50-LED CREE fitting, with a rather impressive 9000 lumen ouput.

When we say bright, it's too bright to look into without ending up with these dark patches in your eyesight, which persist for quite some time!

At 6m distance from the light, illuminance is 401 lux, dropping to 168 lux at 10m. Naturally, at 10m you get a much wider beam spread and is much more suited to the high-level use you'd expect in warehouses, etc.

On top of the LED high-bay is what looks like a traditional mercury ballast but is in fact simply a large heatsink. The 230V mains power supply is separate, on an attached lead. But in effect, the LED high-bay really is a drop-in replacement for the mercury high-bay.

It doesn't have the long "power up" time of mercury lamps – for all intents and purposes, it appears to be "instant on". Measurement does show a slight increase in level over time but you'd be hard-pressed to notice it. And it comes on immediately if turned off and back on again. No more stumbling in the dark saying undeleted expletives!

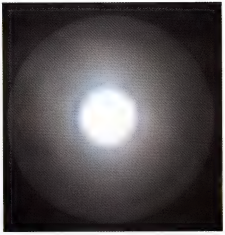
LED life is rated at 35,000 hours – that's four years of 24-hour-a-day operation. LEDs being LEDs, less frequent use would undoubtedly stretch this out much further.

Specifications of this lamp fitting are shown above. Using the same electricity rate as we did for the mercury high-bays, you would save more than $500 each year for each high-bay you replaced. But even better – in a typical warehouse you should be able to use fewer LED high-bays, maybe 20-25% less.

One futher point: all the comparisons are taken with clean lamps. We've found that over time mercury high-bays become very dusty – both the globe and the reflector – which further reduces light output.

LED floodlight

The second fitting is much smaller –



The light dispersion from the fittings is dependent on the position of the light source within the reflector, the amount of collimation (much more in a LED than in a discharge lamp) and shape of the reflector. These three photos were taken from identical distances under the lamps and shows the dispersion. The left pic is that of the mercury vapour (discharge) lamp – wide dispersion and the lamp source at (or close to) the focal point of the reflector. The middle shot is that of the LED high-bay – a rather different pattern from a rather different looking reflector. The right pic shows the LED floodlight, a different shaped reflector again but with much wider dispersion pattern. The LED high-bay is intended to be mounted up high – in large warehouses, for example, it could be ten metres or more off the ground.

in fact, it looks more like a replacement for a traditional halogen floodlight. And so it is, being designed more for outdoor use with an IP65 rating (total dust and low-pressure water protected) and an even higher 50,000 hour rating on the LEDs.

Unlike the single-wattage high-bay, the floodlight is available in 30, 130 and 200 watt versions, with luminous flux of, respectively, 2500, 10,800 and – wait for it – 15,800 lumens! That's for the cool white versions, warm white are significantly lower.

While intended for vertical installation on a wall, (again, being LEDs) we would assume that it wouldn't get upset at being mounted at other angles or positions. The same cannot be said for halogen bulbs – mounting them at any angle off horizontal can (sometimes dramatically) shorten their life.

You might wonder why we included this LED fitting in this review, given the fact that we were basically looking at high-bay replacements.

Well, from experience we know that in warehouses and industrial premises, there are a lot accidents where (for example) a forklift mast takes out a high-bay – especially if there is limited headroom.

We reasoned that these floodlight-type fittings, with a height of only 375mm, could be an ideal replacement. Add to that the polycarbonate/aluminium construction and the IP65 rating and they could be used virtually anywhere. Even the larger 200W model is only 400mm high.

The smaller (and cheaper) 30W model would be ideal for filling in dark corners and, for example, the spaces between pallet racking where the main lights can't quite get to.

The verdict

These LED replacements are not cheap, especially if you have a large area with large numbers of mercury high-bays to replace.

The savings are undoubtedly there, simple maths will tell you that you'd be well in front after a few years.

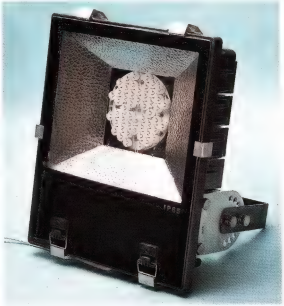
Replacing mercury high-bays, even with the saving, is a significant capital cost for most organisations – but we believe a well worthwhile one. If you're talking a new building, it's a no-brainer!

And if you suffer damage from wayward forklifts (or anything else!) and/or have limited headroom then once again, you really should be looking at the LED floodlight fittings.

Where from, how much?

Both the high-bay and LED floodlight came from Tenrod Australia, 24 Vore St, Silverwater NSW 2128. (02) 9748 0655 www.tenrodlighting.com.au

The high-bay retails for $650.00+gst, while the 130W LED Floodlight sells for $740.00 +gst. For 10 or more there are discounted prices. SC



Here's the IP65-rated (ie, external use) LED Floodlight, with its Cree 50-LED array clearly visible (go on, count 'em!). It really is *very* bright, as our temporary blindness can attest to when taking the photos! While this is designed to replace vertically-mounted wall floodlights, we see no reason why it could not be used horizontally inside or out, especially in areas with limited headroom. In fact, the multi-position mounting bracket suggests it is intended to be used at any angle.

Vintage Radio

By Kevin Poulter & Stan Snyders

Rescued from the junk pile & fully restored . . .

A 1925 Freed-Eisemann Neutrodyne Radio

Salvaged from an old storage shed in outback Queensland, this rare 1925 Freed-Eisemann neutrodyne set was in poor condition, with a dilapidated, water-damaged cabinet and missing parts. Restoring it to as-new condition proved quite a challenge.

FREED-EISEMANN RADIOS were so popular in 1924 that they sold around $US4.5 million worth – more than all the other 12 neutrodyne-licensed brands combined. This type of radio was licensed for manufacturing under the Hazeltine patents owned by Independent Radio Manufacturers Inc.

The Freed-Eisemann company was run by Joseph Freed, Alexander Eisemann and Arthur Freed. They stated in their advertising that they felt "personally responsible" for the performance of their radio sets. These sets were craftsman-built and you can see the high quality right throughout their radios – from the cabinet to the chassis and the overall design.

In 2008, HRSA member Stan Snyders was travelling from Queensland back to his home in Victoria. Stopping for a short break and fuel in the remote outback Queensland town of Surat, he looked for a junk shop. An old wooden storage shed with a concrete and dirt floor and lots of junk looked promising. It was run by a woman supplementing her farmer husband's income during tough drought times.

Scanning the junk, it didn't take long for Stan to spot a real gem. Sitting on the dirt floor with half a petrol-engined water pump on top, was what looked like the back of a 1920s coffin-style radio. When the dust was wiped away, the front panel indicated that it was a Freed-Eisemann Model NR-7.

Unfortunately, it was badly damaged, with the top lid bowed and split along its length, due mainly to the heavy petrol engine that had been placed on top. The inside had also been stripped of some parts and the wooden cabinet was clearly water-damaged. However, the three large RF coils were still in place and so were the three tuning capacitors with their very large black Bakelite knobs.

Sitting next to each RF coil was a UX-base valve socket. Incredibly, each of these sockets was fitted with an 80 rectifier valve, so someone in the past clearly didn't have a clue about what they were doing. The rest of the circuitry was missing.

Only the holes left on the front panel gave a clue as to what may have been there. It was obvious from the layout that the radio had been designed and constructed in two halves. An RF (radio-frequency) section which was largely still present and an AF (audio-frequency) section which was the part that was missing. All the internal wiring still present used solid round

copper wires covered with black cloth spaghetti.

The only cotton-covered wire was a section of the battery cable. The rats had eaten the rest of it. And every cable exit hole had been gnawed around the edges, leaving deep grooves.

The $50 asking price for the set seemed reasonable so Stan asked the proprietress about its history. She told him that it had been found at a local cattle station clearance-sale two years before and was part of an auction lot. Unfortunately, she couldn't remember the name of the cattle station but it was obvious that the original owner had purchased this upmarket set to pick up distant stations like Brisbane.

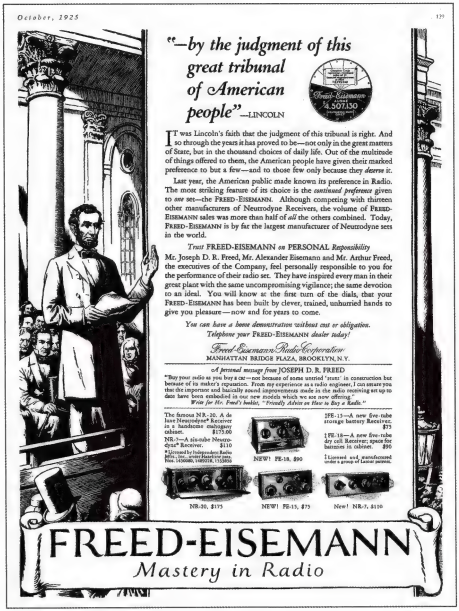
She also said that since the dirt floor of the old shed often flooded when it rained, the more valuable petrol engine had been placed on top to protect it from the water! No matter – this set was too good to pass up, so Stan paid the $50 and took the set with him.

Restoration

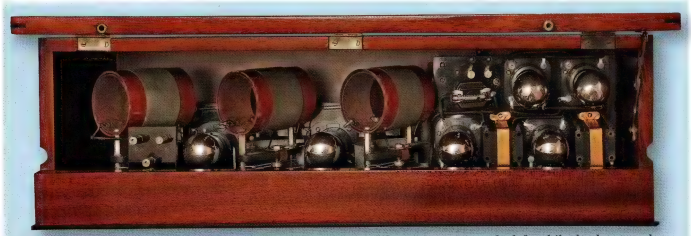
"Old Freed" subsequently sat on the workshop bench for two months, then Stan took digital photos to later serve as a guide when it came to putting it back together again later on. Taking a few photos can be a real time-saver when it comes to radio restoration.

Having taken the photos, Stan began the disassembly. The poor state of the cabinet and other parts meant that it had to be completely stripped down before restoration could begin.

First, the front panel and the attached RF section were removed and put to one side. The rationale at this stage was that if the cabinet could be made to look like new, it would provide suffi-



This 1925 advert for Freed-Eisemann radios boasted that the company had outsold all the other 12 neutrodyne receiver manufacturers combined.



This is the view inside the cabinet of the fully restored receiver. The RF section is at the left, while the detector plus audio stages are at the righthand end. Note the two gold-finished interstage transformers in the audio section.

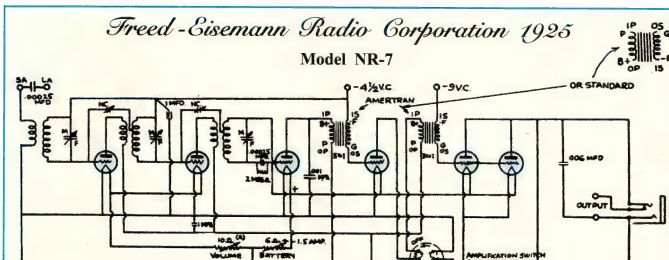


Fig.1: the Freed-Eisemann NR-7 is a battery-powered 6-valve TRF receiver with antenna tuning, two tuned RF stages, a detector stage and two audio stages. Note that the final audio stage consists of two triodes connected in parallel.

cient incentive to restore the circuitry. If not, the radio would be stripped for the parts.

Cabinet

The timber case came apart very easily, the various joints having been weakened due to frequent soaking, sun bleaching and abuse. Each timber panel was then washed in soapy water, then stripped with paint stripper. There were five panels in all, consisting of the three sides, the base and the lid.

The split lid was repaired by gluing the two broken halves together and then clamping them while the glue dried. Two-pack epoxy was used, rather than PVA wood glue.

Next, the four remaining panels, now clean of dirt and paint, were soaked for three days in a bathtub, to prepare them for straightening. The panels were then stacked on top of each other with several sheets of newspaper between them and placed in a hydraulic press. About 200kg of pressure was applied and the set-up left for three weeks, allowing the wood to dry thoroughly. At the end of this period, the panels were perfectly straight again.

Each panel was then thoroughly sanded, starting with 80 grit Free-Cut sandpaper and finishing with 120 grit.

Repairing the damaged rear panel was the most difficult part of the case restoration. Some of the gnawed holes were repaired by simply sanding but others needed major filling. The trick to making a repair invisible is to use the right colour filler and this was arrived at by experimenting on the back of the baseboard. Applying a little linseed oil to a small area brings out the timber's colour – a good indication of the filler colour needed.

"Timber Mate" wood fillers are water-based, non-shrinking and readily available. The trick is to select the filler that's the closest to the desired colour, then fine-tune the colour by mixing in a little colour pigment. Artist's acrylic paint can also be used. Properly done, the repair can be invisible.

At this stage, the case was ready to be reassembled and this was done using PVA wood glue and new slotted wood screws. Any excess glue was removed using a damp cloth before it dried. Once assembled, the case was clamped, checked with a square and the glue allowed to cure for several days.

Restoring the timber colour

The sun, dirt and rain had all taken a toll on the timber and much of the natural colour had been lost over decades of abuse. Stan's friend and woodworking guru, Doug Ellis, had the answer. Before painting, the trick is to prepare a solution of green and yellow pigment in methylated spirits. This solution needs to be weak and translucent and is applied to the timber using a small square of cotton cloth. It's then allowed to dry, after which a second or third coat is applied as required.

When this was done, the wetted wood immediately took on depth and patina. This colour-burst disappears as the methylated spirits evaporates but then returns again when the timber is clear-painted. A light sand using 180 grit is recommended before applying the first coat of clear polyurethane.

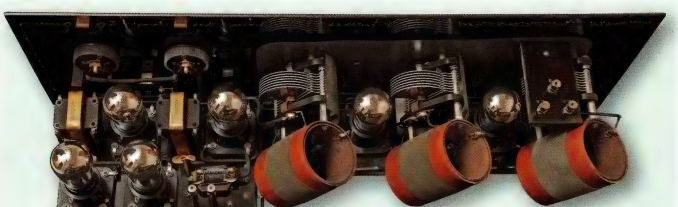
Finishing coats method

Stan achieved spectacular results using satin oil-based clear polyurethane paint. First, three coats were applied, with 24 hours between each application to allow the previous coat to dry.

These first three coats don't need to be carefully applied, as a few brush strokes will make no difference to the final finish (and nor will a few dust speckles). In fact, these first three coats are applied simply to fill the woodgrain and give depth to the finish.

Once the third coat has been applied, the cabinet was left to stand for three days to allow the polyurethane to cure. Stan then used 600 grade wet & dry paper and a solution of warm soapy water to rub back the painted area while taking care not to damage any mouldings. The resulting white milky paste was simply wiped away with a damp cloth during this procedure.

The sanded areas were then left to dry, after which two more coats of polyurethane were applied and left to



Rear view showing the large coils and the two wirewound rheostats. The entire detector/audio board on the left was missing from the salvaged unit and had to be rebuilt from scratch, using photos obtained via the internet as a guide.

cure for another three days. The panels were then again rubbed back using 600 grade wet & dry paper and warm soapy water, as previously described.

Once dry, a final coat of polyurethane was applied using a soft long-haired brush and allowed to cure. This was then gently rubbed back with 0000 steel wool and linseed oil.

The accompanying photos show the end result, with the timbers brought back to life. In fact, the cabinet now looked so good that it inspired Stan to tackle stage two – the electronics.

Parts-gathering

Having restored the cabinet, it then took Stan a further 18 months to collect sufficient original parts to begin restoring the circuit. There were some good finds along the way, with most of the parts, including the missing knobs, coming through eBay and contact with fellow collectors.

One of the most spectacular finds was the unique on-off-volume switch – it was new in its box (1925 stock) and cost just $8! The missing high-shoulder UV sockets (for the short-pin 201 valves) were located, while the 6Ω and 10Ω rheostats came from the HRSA's Valve Bank.

A Google search soon located the circuit, along with photographs of the chassis. This information was invaluable, especially for the missing audio stages. Stan wanted the set to look like it had just left the factory, so authenticity was paramount.

First, the RF stage was disassembled from the black face escutcheon and given a clean with warm, soapy water. The two rheostats and the rotary switch for on/off/medium/loud were missing and someone had badly drilled a jagged 20mm-hole where the switch had been. This hole was repaired using 2-pack cast 306 epoxy resin with a black primary pigment (available at fibreglass stores and craft shops), to match the original colour. The entire hole was filled, then cut with 600 wet and dry and polished, to give an invisible repair.

Cast 306 epoxy is easy to work with and machines really well. It's produced by a company called Solid Solutions in Moorabbin, Victoria. This epoxy is also suitable for making knobs and doing other repairs. Any colour can be made, using primary pigments.

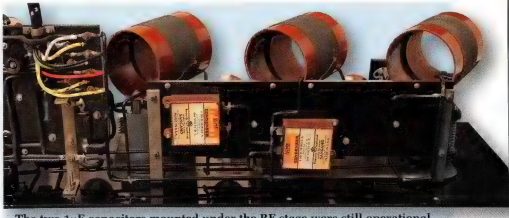
The next step involved restoring all the border lines and lettering on the faceplate and knobs (they had faded to almost grey). All the Freed-Eisemann set's graphics were originally gold, so a 'Power Plus' Contessa Gold (PJ6160) automotive spray can was used (available from Supercheap Auto or Auto-Barn) for this job.

After shaking the can vigorously, Stan sprayed a small amount into the cap. Then, using a very fine touch-up brush, the paint was smeared into the grooves of the letters and edging and left to dry. A second layer was then applied, as required. Once dry, the excess was rubbed off using a fine cotton cloth dipped in a small amount of acrylic thinners.

Valves & audio stage

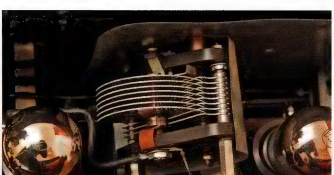
The Freed-Eisemann Model NR-7 used UX-201A triode valves throughout (six in all) but the CX-301A can also be used, as can power triode valves such as the UX171A and UX112. The required valves (UX-201A) were all obtained through various enthusiasts and via the internet.

The missing audio section was made by following photographs of complete NR-7 radios. Two brass brackets need-



The two 1μF capacitors mounted under the RF stage were still operational, while the new multi-way battery cable was obtained from stock especially made for the HRSA valve bank.

The only fixed resistor in the circuit is the 2MΩ grid leak resistor for the detector valve. It's mounted between two clips above a 0.00025μF (250pF) mica capacitor.



This close-up view shows one of the variable capacitors after it had been ultrasonically cleaned, scrubbed with a toothbrush and re-assembled. It now looks like new.

ed manufacturing, so brass stock with the same profile as the brackets in the RF area was obtained from a company in Clayton, Victoria that specialises in brass profiles. This brass stock was then cut and bent to shape.

The most difficult items to acquire were the two interstage transformers. Only originals could be used, as Freed-Eisemann wound their own. They were autograph embossed on the metal band around the transformer and finished in gold plating, so they really looked the part! Once again, the internet came to the rescue.

Grid resistor

The only fixed resistor in the entire circuit is the 2MΩ grid resistor for the detector valve. This clips into two brackets mounted at either end of a 0.00025μF (250pF) mica capacitor (see photo). These parts also had to be replaced.

RF stages

After initially cleaning the RF parts, all three variable tuning capacitors were disassembled and placed in an ultrasonic cleaner. Their aluminium vanes and frames were then finished off by scrubbing them with a toothbrush, after which the bearings were oiled and the parts reassembled. They came up looking like new.

The RF coils are rather large and have khaki windings. However, the coils were very discoloured, so they were removed from the chassis and painted with artist's acrylic paint mixed with water to a runny slurry. This was virtually a dye which the double cotton-covered coils absorbed perfectly. After three coats, the result was exactly as envisaged.

As previously stated, all the wiring in the RF stage used round copper wires covered with heavy black sleeving. This wiring was in poor condition, so it was replaced and covered in heavy black spaghetti insulation.

A new cloth-covered, multi-core DC power cable, obtained from the HRSA Valve Bank, was also installed.

Alignment

The first and second RF stages in Freed-Eisemann Model NR7 need to be aligned (or "neutralised"), with no heater voltage applied to the valve in the section currently being neutralised.

One way of removing the heater voltage would be to unsolder the supply lead to the relevant section each time it's neutralised, then re-connect on completion. However, that's messy and time-consuming, so Stan made an adapter socket, comprising a spare socket mounted on top of the pin assembly from a dud valve. This assembly has the grid and plate connected but not the heater pins.

This simple adapter enables the valve to be 'in circuit' but effectively disconnects the heater voltage.

The alignment procedure is as follows: first, with all valves in place, a radio station at the top end of the band is tuned. That done, one RF valve is removed, placed in the special adapter and the assembly fitted back in place. The relevant neutralising capacitor is then adjusted until no sound is heard.

As an aside, it's also possible to discard the adaptor and simply use a valve with an open-circuit heater. However, it's still better to neutralise the grid and plate of the valve that will actually be used in the set.

Audio levels

When set to its mid-position, the rotary switch applies voltage to the heater of the first stage audio valve. This gives a volume that's more than adequate for everyday listening and can be adjusted by a rheostat, which changes the heater voltage.

Switching to the 'loud' position engages the heaters of a further two 201A's wired in parallel (ie, the second audio stage). If the local stations are too loud, then one of the 201A valves can be removed! Note also that if a power triode valve like a UX171A or UX112 is used in the second stage audio, just one is needed – in either valve socket.

The weakest 201A is used for the detector, as it doesn't need a high mu (voltage gain). The highest mu valve is fitted to the first audio stage, as that's where the most amplification takes place.

The audio output is fed via a phono jack under the 3-position switch. Stan tried horn speakers and headphones but the frequency range of a horn speaker is pretty awful for music. In the end, a PA speaker with an 8-inch (200mm) loudspeaker was used and is connected via an audio transformer with a 7kΩ primary. This improved the listening quality no end.

Performance

In operation, the NR-7 is very sensitive and selective and is one of the best performing sets in Stan's collection. By using a 30m-long wire aerial, stations from NSW, SA and Tasmania are received just like local Melbourne stations.

Stan believes that this excellent performance is largely due to the huge coils that this set uses in the RF stages. They are certainly much bigger than those used by most of the set's other competitors. SC

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Concern over Alcolyser calibration

After reading your Alcolyser article in the November 2013 issue, I felt the need to share my findings about the Jaycar QM-7302 alcohol tester. I purchased one for myself and decided to test it (several times) before trusting it. The results were believable and very consistent.

A friend was also interested, so I purchased one for him. I decided to test that one (several times) as well before giving it to him. But this one proved to be very different to the first; even worse, it read low with nearly half the reading of the first one.

My conscience would not let me give it to my friend, so I obtained a replacement and naturally tested that one as well. It was the same as the previous one. The test involved consuming four standard drinks in one hour and breath samples were taken after each drink. All units tested had new alkaline batteries.

With the second and third units I obtained, one standard drink did not even register. It would give the user a false sense of security and possibly cause him to lose his license.

All that I want is another one that matches my first tester. Do I keep trying more testers? I am 100km from the store that I purchased it from. Can you show your readers how to verify that their tester is not reading low, whether used as an Alcolyser or as a stand-alone tester? (D. H., Mourilyan, Qld).

● Unfortunately, breath testing people after 10 minutes is really not the way to go to check the calibration of the instrument. You need to wait at least 30 minutes and there are huge variations between people so be careful before you drive!

Major breweries and distilleries use a specially standardised and pre-calibrated 0.05% gas line to check breath testing devices. If you don't have this then you need to set up the Alcolyser as described in the article and use exactly 1.0 gram of blended whisky (40% ABV) in 199 grams of water and then the temperature must be exactly 40°C . The reading should be close to 0.22 BAC on the QM7302. This is the only way to establish a "baseline" for your particular device and if it differs, then you can adjust the conversion chart accordingly or return the instrument.

The Alcolyser is designed for testing the alcohol content of liquids and we are relying on the accuracy of the QM7302 as specified. If it falls outside the specifications then it should be returned. We had three of these units and their readings were identical under controlled conditions.

Running a cordless drill with a cord!

OK, you have given us a way to upgrade our cordless drill batteries, in the article entitled "Fire Up Your Cordless Drill", in the October 2013 issue. What about those of us who have the drill and an almost endless supply of power, ie, a nearby power point? Can you now give us a circuit to power our drill from the mains?

Without the heavy battery pack, this would be a great lightweight drill or power driver; the cable hanging off the back is not always a problem. (J. C., via email).

● You should first refer to our article entitled "Recycle Your Cordless Drill – Make it Corded" in the December 2010 issue. The idea in that article is to run it from a variety of 12V DC sources – no circuit has to be built. But we suppose the next thing you'll want is to run a higher voltage drill from a mains supply at, say, 18V or 24V DC?

This is far less practical and is quite expensive. In that case, you need a suitably large step-down transformer with an 18V or 24V secondary winding. You

Fluorescent Light Starter Project Update Wanted

I wonder if I might ask you a question about one of your old "Electronics Australia" projects from the October 1982 issue? The project in question is the electronic fluoro starter which has sparked interest recently during a late night venture into the kitchen to be greeted by the "flash, flash, flash" of the light. I built several of these way back for the lights of my boyhood home and they are still going strong today.

I sourced the article from a friend's collection of magazines, made a couple of PCBs and built them using the DB3 Diacs. Imagine my horror when neither of them worked. I can only assume that the DB3 Diac is similar to the ST4 Diac that the original article warns against. Jaycar advertise the original ST2 in their catalog but they are in fact the DB3s.

May I suggest revisiting this project as a possible inclusion in SILICON CHIP for the future but updated using currently available components? Any idea as to why the current DB3 Diac doesn't work? I am using BT151 SCRs. (P. C., via email).

● That EA circuit should work OK with any Diac that has a symmetrical break-over voltage of about 30V. SILICON CHIP effectively superseded that project with our own design in the August 1996 issue, using a Philips UBA2000T fluorescent starter IC. Unfortunately, the PCB for that project is no longer available.

However, we don't think it is worthwhile updating either project since commercial electronic fluorescent starters are now readily available. If you cannot find one locally, you can get them via eBay quite cheaply.

Low Harmonic Distortion Isn't The Only Important Parameter

I would like to comment on your many ultra high fidelity stereo amplifier projects. I have built a few of these projects over the years including the (famous?) ETI 5000 stereo amplifier and preamp. I have noticed that the emphasis is always on the distortion figures. And you always try to get the distortion figure down as low as possible.

But I do wonder if this the only important parameter in the overall sound performance of a high-fidelity amplifier? Maybe not.

I feel that the emphasis must be also on other things like the dynamics in reproducing the presence of the various instruments in a piece of music to true dimension. I also wonder why amplifiers like the Musical Fidelity (and many others) brand cost thousands of dollars. Surely they do not use gold-plated components but obviously I think the use circuitry and components which reproduce those dynamics of true sounds to absolute precision. I would like your comments on this issue and also your view as to why these amplifiers cost thousands and some many thousand of dollars. (P. T., via email).

● If an amplifier truly has low distortion figures then all those other vague "musical" qualities like dynamics will automatically be good. The fact that some amplifiers cost many thousands of dollars does not guarantee anything. In fact, some very expensive amplifiers do not have low distortion figures at all and are sold on the claim that they are "musical" or whatever.

Incidentally, we did not hold the ETI 5000 in very high regard. Its distortion figures were OK for the time but it used Mosfet output stages which are not particularly linear and they are prone to supersonic oscillation. That is a big problem!

Furthermore, Mosfet output stages provide a relatively high source impedance (by comparison to bipolar transistors) which limits their ability to drive very low load impedances which can occur with some loudspeakers which have savage dips in their impedance curves.

We should add that even some very expensive loudspeakers have very uneven impedance curves which do cause problems with audio amplifiers. In our opinion, such loudspeakers are badly designed.

On the other hand, amplifiers should be able to cope with such speakers and some clearly cannot. Many home-theatre amplifiers are optimised for 6Ω loads and will not work well with impedances of 4Ω or less.

So in a roundabout way, we have indicated that distortion is not the only important performance characteristic. But taking our first comment again, if an amplifier truly has low distortion, these other problems will have been dealt with by the designer.

need to fit a bridge rectifier rated at 20A or more and the transformer will need a rating of around 300VA to cope with the high current demands of a typical cordless drill.

Adjustable switch-off for a golf-cart charger

As a great fan of SILICON CHIP over many many years I always check out my past issues for help with a new project. This time, however, I need some direct help. My project is to get together a circuit that can switch off a golf-cart battery charger at a preset voltage and then reset at a preset lower voltage to recommence charging.

SILICON CHIP has plenty of adaptable projects but none that I can locate to operate in the range of say 10-63V DC. I want both high cut-in and low cut-in presets adjustable, of course, so that it could be used for 36V or 48V systems. There are a few out there in market but they seem to be fairly expensive. (J. N., Mt Maunganui, NZ).

● The most applicable project we have is the Simple Voltage Switch from December 2008. It is not designed for such a wide voltage range but it could be powered from its own 12V plugpack supply and the 1MΩ resistive divider for the signal voltage input altered to divide down to below 8V to suit the input voltage range required. The hysteresis (VR2) sets the low voltage setting, while the reference voltage setting (VR1) is for the upper switch-off voltage adjustment.

A heavier current rating relay may be required, depending on the current the relay contacts need to carry. However, it does seem strange that the golf-cart charger does not already switch off when the battery is charged.

Urbanised possum deterrent wanted

Like many people, we have problems with urbanised possums in Melbourne – soiling the paths, decks etc. I am wondering if you might consider a project to produce an ultrasonic oscillator/amplifier that can be operated over an extended period, ie, overnight? (C. C., via email).

● It would be possible to modify our Barking Dog Blaster from the September 2012 issue but the software would need to be modified for continuous operation. Alternatively, a movement detector could be used to just trigger the unmodified Dog Blaster unit when it detected the possum to sound for the timer duration.

Continuous running would be real noise pollution though and an annoyance to any animals with ultrasonic hearing such as dogs if it were to run throughout the night.

Signal booster for smart phone

Most smart phones are not so smart in the country where signal strength is low. Further, they don't have an external antenna input (my Samsung has a 'service port' that is an antenna connection and I bricked my phone trying it out)!

You can buy passive antenna coupler leads for the right antenna but these do a really poor job compared with a direct connection. Is it possible to improve the signal by a tuned circuit coupler to the phone: eg, on the Telstra 3G network at 850MHz? Is this a project worth pursuing? It would be for me! (P. M., Black Rock, Vic).

● To improve long distance reception

Possible Faulty Micro In Tank Gauge Project

I recently purchased a kit for the Ultrasonic Water Tank Level gauge that was published in your September 2011 magazine. I have assembled the kit and it all works perfectly at the default settings of 330mm (full) and 1000mm (empty).

I can change the empty setting to 1200mm and the unit still works correctly. However, when I try to change the full setting to 70mm or 200mm, all the LEDs flash at the correct rate etc indicating that the new full level has been set but now the only indication I get when S2 is pushed is the full LED on, even if the unit is moved to the empty position.

I am able to reset to the default settings and all works correctly. Is there a way to set the full level to something other than 330mm or have I got a faulty controller chip in the kit? (G. A., via email).

- It appears that the EEPROM location that stores the full setting is not being written to correctly. Check that the 5V supply is within tolerance (4.85-5.15V). You could try replacing the 1µF supply decoupling capacitor at IC1 or connecting a 10µF across the pins (pin 5 and 14 with the plus to pin 14). Then try and recalibrate.

Otherwise it seems the PIC has faulty EEPROM. If you have access to a PIC programmer, you could change the software to use different EEPROM locations and you can reprogram the PIC. That may avoid the faulty EEPROM location. However, the simple approach would be to obtain a new micro programmed with the software.

in the country you need to boost the transmit and the receive signals from the mobile. It is possible to obtain boosters from overseas sources to do this but the big problem is that they are banned in Australia by ACMA (Australian Communications & Media Authority). The only way that you can legally boost your mobile phone's reception is to use it in a car with a hands-free kit and an external antenna.

Another lump in the coax project

Thank you for the Mini Audio Mixer project. What I like most about the design, other than the high quality, is the isolated power supply. This makes me wonder if such a design could be applied to a common audio problem of "levels" when it comes to recording for radio & TV.

Here is my basic understanding of the typical signal levels (using a rough interpretation of dBu):

(1) -40dB = microphone
(2) -10dB = CD player/keyboard/ "consumer level"
(3) 0dB = "Pro-consumer level"
(4) +4dB = "Pro level / studio level"
(5) +10dB = "Broadcast level"
(6) +24dB = "Transmission level"

A problem frequently arises in corporate audio-visual work when members of the media (radio & TV) ask for a record feed from the sound desk. More often then not, the auxiliaries are all wound up to maximum but the signal is still weak with a bucket-load of hiss. This is because their cameras and recording equipment are expecting a minimum of +4dB and ideally +10dB.

Cheap sound desks only put out -10dB on auxiliary outputs and 0dB on the main outputs. Good sound desks bump up the main outputs to +4dB but make high-power auxiliaries an optional upgrade. Broadcast sound desks can easily put out +10dB from any output.

Some film, TV and radio people are happy to use a middle of the range sound desk for their own personal mixing and only ever use the main outputs (+4dB). However, in the corporate AV world, the main outputs (from a middle-of-the-range sound desk) are usually driving the PA system, so the media feed has to come from the auxiliaries (-10dB and usually unbalanced).

There are some nice active media splitters on the market (Quest, Whirlwind, Leon Audio, ARX) which can balance a signal and add around 12dB of gain. Typically, these offer 12 channels and cost thousands of dollars.

I was thinking that Silicon Chip could design a new device like a 2-way or 4-way splitter which could take a balanced/unbalanced -10dB input and boost it up to +10dB balanced/unbalanced output. This would be a handy piece of kit for freelance media who want the best possible audio signal for their recordings.

I'm guessing that aiming for +24dB may be a little excessive as my calculations suggest that this would require supply rails of ±18VDC. Maybe this could be an optional upgrade for very long cable runs. There are some line level shifting devices on the market (both active and passive). The active devices use plugpack power supplies and seem to add noise and distortion.

WARNING!

Silicon Chip magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

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The passive devices sound muffled, with a reduced bandwidth. A self-powered device with clean sound like the "lump-in-the-coax" would be nice. (P. S., via email).

● Designing a device such as you are describing should be possible. It would probably need to draw more current than the Lump-in-Coax to give good noise performance but you could still get hundreds of hours from a small Li-Po battery.

We would design something similar to the "High Performance Microphone Preamplifier" from September 2010 except that it would use a lower-noise rail-to-rail op amp such as the TL974 which draws 1.4mA/amplifier but has performance similar to the NE5532 or LM833. A pair of these driving a balanced output from a 4.2V rail should be able to deliver nearly 3V RMS which equates to +11.7dBu.

So it should be possible to amplify from -10dBu to between -10dBu and +10dBu using a single-cell LiPo battery and with a signal-to-noise ratio of over 90dB. As you suggest, to get +24dB would require a more complex power supply or mains power but that would be possible.

Queries on power Mosfets

I have a query about power Mosfets. High power FETs come in the TO220 package. Some can pass up to 50A, yet their connection leads are very thin with small spacing between leads. I guess the leads are larger than 50A fuse filaments but they are well under the specification for the size of a copper conductor necessary for limiting excessive heat build up (at 50A).

Why do the leads not blow at high currents? Say I wish to connect a FET to a 15A size conductor: How could this be done with such small lead spacings?

On another matter, some project articles state that gate drive should not be hindered with too much series resistance, yet the FET in the reverse polarity protection circuit in the Circuit Notebook pages of the April 2012 issue uses a 100kΩ gate resistor! What are the design parameters when it comes gate series resistance? (H. W., via email).

● You are right that TO-220 package legs are thinner than a copper conductor rated for 50A+ (some TO-220 devices are rated up to about 100A). But the thickness of a conductor isn't the only variable – there are other factors.

First, they're quite short, which helps because for such a high-current application you will generally heatsink the TO-220 package and this also effectively heatsinks the leads (although to a lesser extent). But there's also the issue of how much temperature rise is tolerable. Normally cable diameter is chosen based on a maximum temperature rise of something like 10°C. Obviously it will take a lot more heat than this to melt a wire so you can use thinner cable if you are willing to accept the higher operating temperature and attendant power losses.

Usually we don't want to waste too much power in a cable so we use the thicker type at high current but TO-220 device leads are short enough that it doesn't really matter. Note that they usually flare out near the body and ideally they are soldered so that this flared section is as close to the solder joint as possible.

Also, the current limit for the package is normally set by the much thinner internal bond wires which connect the leads to the die anyway (except the drain which is often connected directly to the substrate). Those can definitely fuse if you drive enough current through the device.

Note that TO-220 package lead resistance is enough of an issue in high-current applications that SMD FETs are generally preferred and offer a lower $R_{DS(on)}$ figure. The leads in a TO-220 package add something like 2mΩ to the total resistance of the device

Digital Audio Delay Design Question

I built Nicholas Vinen's Digital Audio Delay (December 2011) and it's now working. The article cites a discontinued Jaycar universal remote and its set-up code. I already have a Logitech Touch universal remote but it uses on-line configuration which expects you to input the VCR model. So now I'm trawling the web looking for Philips VCR model numbers but nothing seems to work.

What strikes me as strange is that 'mute' is used as one of the codes. Why would a VCR have a 'mute' function? So now I'm thinking it's a TV with built-in VCR but I still can't find it. My question is, what criteria did he use in choosing the RC5 codes? What is the TV/VCR model? (M. I., via email).

● Unfortunately, the booklets that came with the Jaycar AR1729 and Altronics A1012 remotes don't specify which model(s) each code covers. They just give a device type (TV, VCR etc), manufacturer and then a list of possible codes which presumably cover the remote control codes used for the most popular models from that manufacturer.

The main criteria used to select the codes was that they had to be Philips RC5 codes which gave the same button mapping on both remotes. We ruled out the default Philips TV code since we've used it in a number of projects in the past and we wanted to avoid conflicts. For example, this project could be used with the Stereo DAC or Ultra-LD Mk.3 Amplifier, both of which default to the standard Philips TV code so there would be a conflict.

As you say, there were a number of combined TV/VCR units. Many of the VCR code combinations map the volume control buttons to the same brand of TV so that if you bought a matching pair, you can control both without having to switch between multiple remote modes.

The mapping used is the standard Philips VCR code, ie, the system number is 5. This is assigned by the standard to VCR #1 (see http://en.wikipedia.org/wiki/RC-5). The button mappings appear to be the standard VCR code mapping except for volume up/down which as you point out are TV codes plus mute. The feature is called 'punch through', where using a remote control set for VCR (or DVD or satellite) will send the TV volume and mute codes when these buttons are pressed. So the volume and mute will operate the TV, while the transport codes for the VCR will operate the VCR.

Given that two different universal remotes had this particular mapping, we assumed that it would be relatively common. When Jaycar discontinued the AR-1726, we tested another universal remote that they now sell (AR-1723) and found that it worked with this project using code 0860, giving the same codes.

Electronic Ignition System For Single-Cylinder Suzuki

I'm having a problem with the electronic ignition kit that I have assembled. I have now completed building two kits, one from Jaycar and one from Altronics. Both passed the initial tests no problems, then when trying to set the kits up to my 1997 Suzuki DR650 engine, both have gone up in smoke.

I'm not sure where I'm going wrong. Both kits have burnt out the track on the PCB that goes from the ground to one of the legs on transistor Q1.

The kits are set up for a reluctor input. The engine is a single-cylinder but has two spark plugs running off one coil (not sure if this is the problem). The first kit is a mess as I was playing around with it during the testing stage and running it for a long period through both spark plugs. It appears to have burnt out Q1 as well as the ground track.

The second kit, from Altronics, appears just to have burnt out the PCB track from the ground to the leg that connects to Q1. I had 4.97V on the initial voltage test and VR1 was almost fully anticlockwise for the initial spark test. VR2 was turned about 1/4 of a turn clockwise.

When testing the second unit, wired up to the reluctor, I did have spark across both spark plugs but only for a very short time before the track on the PCB smoked up. No links were bridged at this time. One thing that I'm not sure about is that there are two wires going to the coil. The instructions only seem to mention a single wire which goes from the ignition kit to the negative on the coil.

I have connected the positive from the battery to the other coil lead. Is this correct? I'm not very savvy with electronics, so I'm presuming I've made a very fundamental error and you should be able to set me straight! (L. P., Geraldton, WA).

● The wiring of the ignition is probably correct although your ignition coil could have a ballast resistor that is connected in series with the coil primary. The original coil wiring should be kept only with the coil negative wiring changed to connect to Q1. This is shown on the circuit where the primary connects between +12V (via a ballast resistor if it uses one) and the collector of Q1.

It does seem possible that the dwell setting is faulty, allowing high coil current after saturation (full coil charge).

Before connecting to the ignition coil, check that the dwell trimpot is working. Connect your multimeter between TP GND and TP1 and check that the voltage can be varied from between 0V for full anticlockwise rotation and 5V for full clockwise rotation of VR1. Check also that pin 18 of IC1 varies in voltage as VR1 is adjusted.

You do need to set VR1 so that the spark is at its maximum but not too much clockwise from this setting so as to cause excessive coil current. The PCB track can be repaired with a piece of tinned copper wire between the emitter of Q1 and the GND terminal on the PCB.

and there are now quite a few Mosfets available with a total on-resistance of less than this, so they have to be in a different package.

Current doesn't have much to do with required lead spacing, other than by limiting the area available for pads and solder joints. Close lead spacing as used in TO-220 does limit the maximum voltage though, to about 1000V before breakdown can occur between the leads.

The reverse polarity protection FET doesn't have to switch fast, hence a 100kΩ gate resistance is appropriate. Normally, power supply polarity will change every few seconds at worst. For a Mosfet operating at 100kHz, the gate resistance must be less than about 100Ω or else this will slow down charging/discharging of the gate capacitance too much and cause unacceptable switching losses and switch-on/switch-off delays.

Depending on the drain current, even 10Ω may affect the performance. Think of the gate like a capacitor of about 470pF-4.7nF (higher-current FETs tend to have more capacitance). This capacitor must be charged to say 10V to turn the Mosfet fully on and discharged below about 3V to turn it off. It isn't exactly a capacitor but it's close enough to understand what's going on.

Temperature switch for ceiling space fan

In order to reduce the heat entering my upper floor bedrooms and hours of use of an air-conditioner, I am going to attempt to remove/reduce the hot captured air in the roof void. Whirly Birds just don't appear to move a sufficient air volume. I propose to do this with a 150mm diameter Manrose "Thru Roof mounted fan" model FAN1060, 46 watts, 38dB, 320m^3/hr.

The roof is Colourbond steel over sisalation. There are R3.5 batts over plasterboard ceilings, with ducted air-conditioning. In summer, there is a difference of nearly 20°C between the roof void temperature and that in the bedroom and it takes several hours for this heat to dissipate in the evening.

The roof volume is about 200 cubic metres, giving me about 1.5 changes per hour. In addition to an overall bedroom wall-mounted master mains switch, when 'on' I would like an additional control in series as follows: The control is a knob on a calibrated scale, say 30-60°C. Selecting a knob setting of say 40°C would switch on the fan when the air in the top of the roof void reaches 40°, then switch off when back under 40°C. Actually some hysteresis of say 3-4°C would prevent the fan from cycling too often. I am assuming that outside air will leak into the roof void via the eaves.

So what I need is, say, a thermistor at fan level and below in the bedroom, the master switch and a temperature control knob. Has Silicon Chip made such a smart kit or something I could modify or do you have a suggestion? (D. K., via email).

● The temperature switch as published in the January 2007 issue can be used as a fan control thermostat. You could calibrate the set point control for the 30-60°C range and even put extra resistance in the top and bottom leg of the set point control to optimise the control range – say 100Ω in the connection of VR1 to the 8V rail and

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1kΩ in the VR1 connection to ground.

For 230VAC mains switching, you would require a mains-rated relay (Jaycar SY4040) instead of the one on the Temperature Switch. The circuit could run from a 12V 500mA plugpack. The hysteresis is adjustable. Jaycar sell this as a kit, KC-5381 (**www.jaycar.com.au**)

MPPT charger needs solar panel input

I recently completed the MPPT Solar Panel Charger for use with a small camper van and all works fine. It is the upgraded second version of the original in the February 2011 issue. However, the rest of the electrical system needed an overhaul. A regulated mains power supply is set to produce 13.3V and this is permanently connected to the battery in normal use. Clearly, this system will never be able to fully charge the battery and what's more, it

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has a small drain and consequently the battery slowly discharges when the van is not in use.

So it seemed reasonable to increase the output of this power supply and connect it in parallel with the solar panel input (120W) to the MPPT, using a MOSFET as a protection diode in the power supply's output. I guessed at setting the supply output to 17V since this is just below what the panel would produce when charging via the MPPT. It was not my intention to have both power supply and panel charging simultaneously although it will depend on the software as to whether this will be OK. In fact, the input to the MPPT from the panels is 15.8V during bulk charging and this seems to charge the battery more quickly than using the power supply.

The results were interesting. Using the power supply, the MPPT went into bulk charging mode as expected but the bulk charging LED flashed off briefly about every four seconds. In the description, it says that if the battery voltage is lower than 10.5V, the MPPT will charge in bursts with the LED flashing every four seconds before bulk charging begins.

By this, I presume that the word "flashing" means it is on briefly every four seconds but in this case, it is off briefly every four seconds. In fact, the battery voltage was around 12V so perhaps this is a coincidence. So I have two questions. Is my arrangement to have the power supply charge the battery via the MPPT reasonable? What could be the reason for the brief flash off every four seconds until bulk charging ends?

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By the way, I particularly liked the series on TV dongles. What a superb and interesting set of articles. (D. W., via email).

- The MPPT charging assumes that a solar panel is connected rather than a power supply. If using a power supply instead of a solar panel, it would be best to use a current-limited supply set for around 6.6A at 18V. That is because the MPPT charging works on the fact that the current will drop as the solar panel is loaded. The solar panel output follows the VI curve as shown in the article – see Fig.1 in the February 2011 issue.

The flashing of the LED during bulk charging is indicating the way the MPPT system works by periodically checking the panel to set up for maximum power from the panel. The LED indicates when this is happening.

12/24V switching for a solar panel regulator

I write concerning the "12V/24V Regulator for 70W Solar Panels" in the September 2013 issue.

I have a query relating to the use of links L1 & L2 for the 24V and 12V versions, respectively. Could these links be replaced by a single DPDT switch (eg, Jaycar's ST-0575 or ST-0576 etc) to enable me to switch between the 12V and 24V modes, depending on the proposed usage at the time?

If so, what switch type etc, would you recommend? (P. M., Karabar, NSW).

- That's a good suggestion. Since the switch effectively has to carry the full output of the charger, it should have a heavy current rating. Jaycar's ST-0576, a 10A DPDT switch with a centre-off position, would be the better choice. Mind you, the switch should not be operated while a battery is connected, otherwise the Mosfets might be damaged. In fact, disconnecting the battery between uses and not using the centre "Off" position on the switch would be prudent. SC

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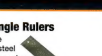

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